Vol. L. No. 8.

TABLE OF CONTENTS.

(20 pages, with inset.)

ENGINEERING NEWS OF THE WEEK 153
LEADING ARTICLES:
The Construction of the Simplon Tunnel, II (illustrated) 154
Drainage of Irrigated Lands ..... Ernest McCullough 158
The Manufacture and Properties of Nickel-Steel ..... Albert Ladd Colby 160
Laying a High-Pressure Gas Main Across the Mississippi River at New Orleans (illustrated) Thomas D. Miller. 164
Unusual Wear in Cedar Paving Blocks; Duluth, Minn. (illustrated) 166
Railways in India 166
Electric Conduit Construction at Cincinnati, O. (illustrated) 167
Scaffold for Use in Finishing Exterior Building Walls (illustrated) 169
Air Relief Valves for Pipe Lines (illustrated) 169
Street Cleaning in San Francisco ..... L. M. King. 169
A Standard Culvert for New York State Highways (illustrated) 170
Some Theories Upon Railroad Location ..... J. G. G. Kerry. 170
Some Municipal and a Military Acetylene Gas Plant ..... J. F. Tilley, Jr. 172
EDITORIAL COMMENT.—A New Process of Combustion—Lessons of the Paris Underground Railway Accident—The Limits to the Production of Nickel-Steel 162
EDITORIAL.—Lessons in Sanitation Afforded by a Recent Typhoid Epidemic at Marshalltown, Ia. 162
LETTERS TO THE EDITOR.—Strips of Macadam in Residence Streets: Wm. G. Raymond—Mountain Tunnels and Switchback Lines; "Railway"—Metal Curb for Masonry Bridge Abutments (illustrated): C. H. Cartlidge—Note and Query 163

THE FLOW OF WATER OVER THE VARIOUS FALLS in the Yosemite Valley, California, was measured in June of the present year by Mr. S. G. Bennett, Hydrographer of the U. S. Geolgical Survey. At the time of the measurements the flow of the various streams, according to the superintendent of the park, was normal for June. The records were as follows, the first set, or those for the Yosemite Falls, being the flow on June 24, and the others the flow on June 26, both in 1903:

Yosemite Creek, below Yosemite Falls, 119 cu. ft. per sec., or 53,400 gallons per minute.

Merced River, below Nevada and Vernal Falls, 853 cu. ft. per sec., or 382,800 gallons per minute.

Illilouette Creek, below Illilouette Falls, 228 cu. ft. per sec., or 102,388 gallons per minute.

Tenaya Creek, below Mirror Lake, 159 cu. ft. per sec., or 71,400 gallons per minute.

Bridal Veil Creek, below Bridal Veil Falls, 20 cu. ft. per sec., or 9,000 gallons per minute.

The total flow of Merced River, below the mouth of Bridal Veil Creek, was about 1,380 cu. ft. per sec., or 620,000 gallons per minute, or nearly 900,000,000 gallons a day.

WATER POLLUTION SUITS against the village of Ballston Spa, N. Y., on account of the pollution of a creek by sewage, have been settled, it is stated, for $7,275. The original claims, made by 43 claimants, aggregated some $21,500.

EXTENSIVE IRRIGATION WORKS IN INDIA, according to a press dispatch from Simla, have been recommended in a report made by an irrigation commission. The proposition is to spend $150,000,000 during a period of 20 years in the construction of what are classed as protective works besides making loans of $2,000,000 a year for private irrigation works. Protective works are here contrasted with productive or income yielding works, the former being designed as a safeguard against famines and as a means of increasing the general prosperity of India.

A LARGE FLOATING DRY DOCK was launched recently at the yards of the Raritan Dry Dock Co., Perth Amboy, N. J. The dry dock is what is termed a solid box dock; it is built of wood and has dimensions as follows: Length, 212 ft.; width, 92 ft.; depth of hold, 12 ft.; total height of sides, 39 ft. 9 ins. The length is increased to 302 ft. by outriggers, 45 ft. long at each end. The dock can lift 4,000 net or 4,150 gross tons, and can have 22 ft. of water over the keel blocks. The dock is fitted with patent adjustable keel blocks and two sets of bilge blocks, which make it possible to dock vessels of widely different shape without pumping up to adjust the blocks. This dock is stated by its builders to be the largest wooden solid box dock ever built.

THE POWER HOUSE FOR THE RAPID TRANSIT Railway of New York city is expected to be completed about Jan. 1, 1904, if no further delays are encountered. This power house will be capable of furnishing 132,000 HP., and it occupies an area of land 700 × 200 ft. between 58th and 59th Sts. and Eleventh Ave. and the North River. There will be 72 boilers of 500-HP. each. The coal supply needed for each 24 hours will exceed 1,000 tons. The storage capacity for coal will be 25,000 tons. The coal will be conveyed to an elevation of more than 80 ft. above the street by belt conveyors, and then it will be fed down to the boilers as fast as needed by automatic stokers. After the coal has been consumed the ashes will be run off the grates to cars, which will run a short distance to the riverside, and dump their contents into scows. The water for the plant is taken from about 100 ft. out in the river, and is conveyed to the Eleventh Ave. end of the plant and forced through the boilers by pumps. The chimneys will reach a height of 265 ft., and will be of brick. The plant is equipped with two electric cranes, one of 60 and the other of 25 tons carrying capacity. The power for the subway system will be conveyed to eight distributing stations, where the current will be transformed for driving the cars. The outside walls of the building are cut granite up to a given point, and above that of terra cotta and pressed brick. The interior is lined with chocolate and cream colored brick, and above the second story with buff brick. The windows are all of steel frame. The roof is to be of terra cotta and glass, with copper conductors. There are to be over 12,000 tons of steel in the building.

TWO TURBINE-DRIVEN SCREW STEAMERS have been ordered by the Midland Railway Co. of England, as a part of a fleet of four steamers to be completed for next summer's traffic between England, the Isle of Man, and Belfast. Triple expansion reciprocating engines will be employed in the other two vessels, which will have twin screws while the turbine boats will have triple screws. All four steamers will be vessels 330 ft. long, 40 ft. beam, and 25 ft. depth, with a gross tonnage of about 1,900. The vessels have been designed by Prof. J. Harvard Biles.

THE EXTENSION TERMINAL IMPROVEMENTS of the New York Central & Hudson River R. R. will be carried out by the O'Rourke Engineering Construction Co., of New York city. The contract price is stated to have been about $4,500,000, and the work is to be completed within 2½ years. The work will be done in three sections and each section is expected to be in operation before the next is begun. The first section includes from 45th St. to 50th St, east of the present yards, and the subway under the east roadway of Park Ave. The second section runs from 42d St, and includes a part of the sub-station where connection will be made with the rapid transit system. When this second section is finished the contractor will begin the western side of Park Ave.

A TRANSCONTINENTAL RAILWAY RECORD was made by Mr. H. P. Lowe in a special trip from New York to Los Angeles to reach a sick daughter before her death. He left New York city at 2.45 p. m., Aug. 4, and arrived at Los Angeles at 1.06 p. m., Aug. 7, making the total time of the trip 73 hrs. 21 min. The last two-thirds of the trip was made over one line, the Atchison, Topeka & Santa Fe Ry. from Chicago, Ill., to Los Angeles, Cal., a distance of 2,256 miles. The time for this section was 52 hrs. 51 min., and the average speed, including stops, was therefore 42.7 miles per hour. The total distance from New York to Los Angeles is about 3,240 miles, and the average speed over this entire distance was nearly 44.2 miles per hour.

THE DISCOVERY OF A NEW METAL called selium by Edward Mollard, a Frenchman, is reported to the State Department. The discoverer asserts that selium costs only one-twelfth as much as aluminum and is lighter and stronger. It does not rust and is therefore suitable for shipbuilding, for the manufacture of pipes and for railroad construction. It is asserted also that it is capable of taking a fine polish resembling nickel. Its hardness is not quite equal to that of iron, but is greater than that of lead or zinc. Its strength is said to be greater than that of iron, but less than that of steel.

THE MOST SERIOUS RAILWAY ACCIDENTS of the week were: (1) A butting collision on the Canadian Pacific Ry., near Sharbot Lake, Ont., on Aug. 13. A freight train ran into a light engine, through some misunderstanding of orders. Two men were killed. (2) Equally bad was a butting collision between two freight trains on the Pennsylvania R. R., near Radnor, Pa., on Aug. 15. The collision occurred in a fog. Two men were killed. —A butting collision between passenger trains on the Chicago, Milwaukee & St. Paul Ry., near Long Lake, Ill., on Aug. 17, caused one death and two probably fatal cases of injury. Several other fatal railway accidents occurred during the past week, each claiming one victim. That electric suburban and interurban railways are taking their place with steam railways in contributing to the accident list is shown by a fairly regular number of accidents. One of the most recent is a collision which occurred on the Cleveland & Southwestern Ry., near Cleveland, O., on Aug. 11. A west-bound baggage car went into an open siding in which stood a work-train. The motor-car of the latter was telescoped by the baggage-car; one man was killed and one badly injured.

THE SECOND LARGEST CANTILEVER BRIDGE in Great Britain has just been completed on the new extension of the Callender and Oban railway in Scotland. This extension crosses both Loch Etive and Loch Creran, and it is at the crossing of Loch Etive that the new bridge is located. At the points of crossing the Loch is 600 ft. wide and the rapid current made it impossible to locate piers in the channel or to employ false works. A long span cantilever structure was, therefore, decided upon by the engineer, Sir John Wolfe Barry. The two main piers were located 524 ft. apart, center to center, and this distance is the span of the bridge. The anchor arm of each cantilever is 105 ft. 7 ins. long and the channel arm of each is 146 ft. long. The channel arms carry a suspended span 232 ft. long. About 2,600 tons of steel were employed in the bridge and the steelwork was manufactured and erected by Arrol's Bridge & Roof Co., Ltd., of Glasgow, Scotland.

TRAFFIC ON THE MANCHESTER SHIP CANAL for the first six months of 1903 shows a satisfactory increase over the preceding six months, according to the report of the Board of Directors recently published. The weight of toll-paying merchandise which passed over the Ship Canal during the two half-yearly periods under comparison was:

	Six mo's end. June 30	
	1902.	1903.
	Tons.	Tons.
Sea-borne traffic	1,457,523	1,695,333
Barge traffic	132,840	140,472
Total	1,590,363	1,835,805

The result of the half-year's working of the Ship Canal Department was an increase of £22,819 in the receipts, of £7,314 in the expenditure and of £15,505 in the profit, as compared with the corresponding half of the year 1902. The export of coal, stimulated by the exceptional demand from the United States, accounted for 122,271 tons of the total increase of 237,810 tons in the weight of sea-borne traffic. The balance, 115,539 tons, consisted of general merchandise.

A 100-IN. DRIVING-WHEEL LATHE, capable of taking in wheels of 100 ins. diameter, is one of the new machine tools installed at the shops of the Chicago, Milwaukee & St. Paul Ry., at West Milwaukee, Wis. In a test made with a pair of 84-in. wheels, the tires were turned simultaneously, with an average depth of cut of 5-16-in. at each tool, and a feed of 3-16-in. The cutting speed was 18½ ft. per minute, and the work was done in 63 minutes. The average power required at the motor was 16½ HP., increasing to 22½ HP. when hard spots were encountered by the tools. The lathe weighs about 56 tons, exclusive of its motor, and was built at the Bement & Miles shops of the Niles, Bement & Pond Co., Philadelphia, Pa. It is driven by a 20-HP. electric motor, built by the Milwaukee Electric Co., of Milwaukee, Wis.

TRACTION ENGINES IN SOUTH AFRICA are being employed in several cases for hauling coal from the railway to mines which have no direct railway communication. Formerly ox wagons were used, but oxen are now very scarce, and the engines are much more economical. The cost of an ox wagon, including Boer driver, native attendant and maintenance, is estimated at $5 per day. It will average 16 miles in 24 hours, so that it can deliver one load of 7 tons at a distance of 8 miles. This gives a cost per ton-mile of 8.9 cts. A steam traction engine can haul 20 tons of coal and can travel 20 miles in 8 hours. The cost for this 8 hours' service is $10—$5 for the driver, $2.50 for fuel and maintenance, and $2.50 for supplies and maintenace of wagons. This gives a cost per ton-mile of 5 cts. In both cases the time occupied in returning empty is allowed for. At the present time there are said to be about 12 engines and 70 wagons employed in freight transportation, and mainly hauling coal.

THE WATER POWER OF THE CHICAGO DRAINAGE Canal is to be developed, after some years of investigation and delay, by the Sanitary District. At Lockport, the canal will be extended south about two miles, and near the present controlling works there will be a power house, with turbines utilizing the power from a fall of 34 ft. The tail race will be about 1½ miles long, extending to the lower basin at Joliet. There will be seven electrical generators of 5,000 HP., each driven by three pairs of turbines on a horizontal shaft. A lock will be built to provide for navigation. The cost of the work is estimated at $2,750,000, and it is expected that it can be completed in two years. Mr. Isham Randolph, of Chicago, is Chief Engineer, and bids for the work will be received until Oct. 7.

THE CONSTRUCTION OF THE SIMPLON TUNNEL.

II.

The Working Plant and Its Accessories.

The contract time for constructing the Simplon Tunnel, 12.4 miles long, was 5½ years, and the course of events has shown that this allotted time was none too long. To carry on a work whose duration was half a decade, the two parts of which were separated by a dozen miles, and the whole of which was located far from the nearest centers of mechanical industry, obviously necessitated a working plant of unusual dimensions. This working plant had, moreover, to be divided into two separate plants, one at each end of the tunnel, each independent of the other and complete in itself. Each plant had to supply power and to provide means for ventilation, illumination, air refrigeration, drainage and transportation service. For each plant there had also to be workshops in which machinery and tools could be repaired. There had then to be provided houses for the workmen and engineers, water supply, hospital service, sanitary conveniences, stores for provisions and materials, and a multitude of minor necessities.

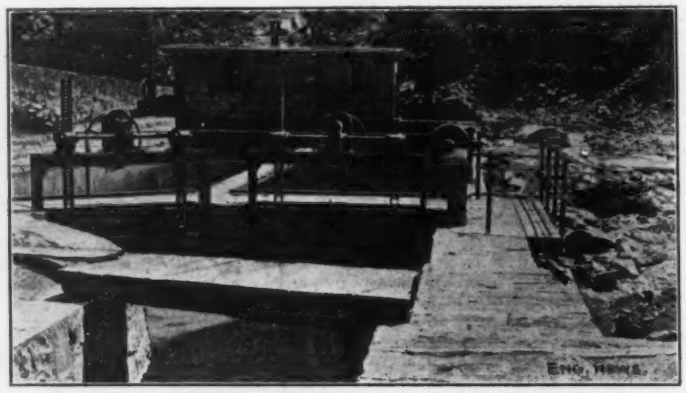


FIG. 1. VIEW OF GATE HOUSE AND FOREBAYS ON DIVERIA RIVER NEAR GONDO.

The two plants at the opposite ends of the tunnel are as nearly as possible duplicates. At the Swiss end the entrance is located 2 miles east of Brieg at 685.7 m. (2,246 ft.) altitude, beneath the hills rising from the bank of the River Rhone, and on this narrow and level bank the working plant is laid out with great uniformity. At the Italian end the plant is located in the deep valley, or the Val Verde, at the upper end of which are the tunnel entrances, and the topographical conditions here are such as to prevent a regular lay out. The following description of the various installations of the working plant applies, with very few exceptions, to both the Swiss and Italian ends, but the specific structures described are those at the Italian end unless otherwise stated. For sake of convenience we have divided the description under the following heads: Power Installations; Ventilation; Air Refrigeration; Illumination; Drainage; Work Shops; Buildings and Accessories; Transportation Service.

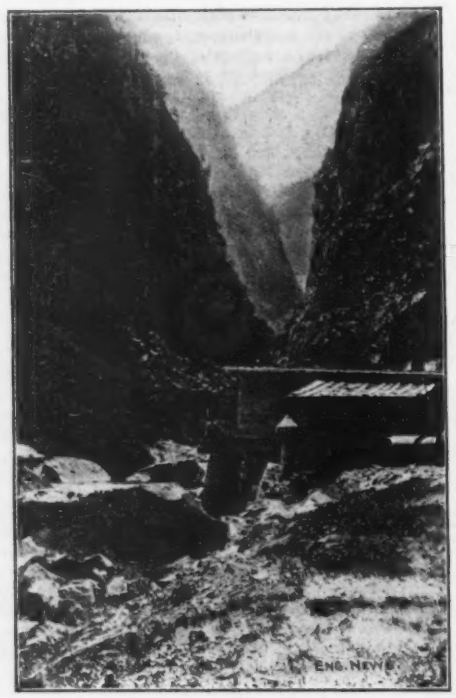


Fig. 2. View Up the Valley of the Diveria from Below the Gate House Near Gondo.

POWER INSTALLATIONS.

Water power is employed for practically all purposes at both ends of the tunnel. At the Swiss end about 2½ miles upstream from the tunnel entrance the River Rhone is dammed, and the water collected into a number of reservoirs provided with the necessary gates for controlling the inflow and outflow. From these reservoirs the water is conveyed for about two miles in a reinforced cement flume. This flume crosses a flat and well cultivated plain. At the point where this plain drops steeply to the Rhone valley the conduit changes from rectangular flume to two cast-iron pipe lines in trench which reach to the power house, a distance of about one-half mile. An air inlet pipe located at the brow of the hill serves both penstocks. The total power available from this service is 2,200 HP.

At the Italian end the power is derived from the Diveria, about 2½ miles above the works, and near Gondo, the last village in Swiss territory. Here the river is dammed, and the water collected into a forebay 80 m. (262.5 ft.) long, from which it is admitted into delivery reservoirs having a superficial area of 270 sq. m., and a depth of 2½ m. (8.2 ft.). At the lower ends of these reservoirs there are overflow weirs, washout sluices and the regulating gates for controlling the supply to the penstocks. The gate house and reservoirs looking upstream are shown by Fig. 1. Fig. 2 is another view which is chiefly interesting as showing the picturesque setting of the works just described. All the way from Gondo to Paglino, the first village in Italian territory, the Diveria is bordered by the sheer mountain heights shown and its bed is strewn with boulders and rock masses weighing from a score of tons to several thousand tons.

From the gate house the penstock for a distance of 1,300 m. (4,265 ft.) is carried along underneath the Simplon Road, shown on the left-hand in Fig. 1, and consists of cast-iron pipe 90 cm. (2.95 ft.) in diameter, built in 6 m. (19.68 ft.) lengths, with shells 1 in. thick, each weighing 4,400 lbs. This pipe was furnished by W. Bosshardt, of Zurich, Switzerland. Near Paglino and about 24 m. (78.74 ft.) before the termination of the cast-iron pipe line there is an escape pipe with an adjustable disk cover designed to reduce the pressure from 118 lbs. to 103 lbs. per sq. in. This escape pipe is shown by Fig. 3. Before this escape valve was installed, about two years ago, the cast-iron pipe was continually bursting under the water pressure.

At the end of the first 1,300 m. (4,265 ft.) the cast-iron penstock is replaced by one of wrought-iron pipe of the same diameter. This wrought-iron penstock continues to the power plant 2,840 m. (9,317 ft.), and has a ¼-in. shell. It was supplied by Rieter & Co., of Winterthur, Switzerland. This pipe line is carried along against the wall, which retains the Simplon Road, being supported on granite piers, and enveloped in a sort of matting, which serves to protect somewhat the metal from variations in temperature. A little above Iselle the pipe line is carried across the Diveria by a suspension cable arranged as shown by Fig. 4. Further on a jutting bluff is penetrated by a tunnel 282 m. (925 ft.) long. Here also the penstock is enlarged to a diameter of 1 m. (3.28 ft.) for a length of 181.7 m. (596 ft.) above the power house turbines. The total head of water on these turbines is 170 m. (558 ft.), but the turbines of the ventilation house further upstream work under 10 m. (32.8 ft.) less head. It should be noted also that the pressure at the power house turbines can be varied from 13 to 17 atmospheres by means of the escape valve at Paglino previously described. Just before reaching the power station the pipe line again crosses the Diveria, this time on the double deck bridge shown by Fig. 5. This bridge also serves to connect the high road with the station and for the carriage of materials between the works on the opposite banks of the river. It was constructed by the Societa Nazionale delle Officine di Savigliano, of Turin, Italy.

The power house contains three Pelton wheels furnished by the well-known firm of Escher, Wyss & Co., of Zurich, Switzerland, two being 250 HP. each and one of 600 HP. All three wheels are horizontal and run at 170 revolutions per minute. They operate the pressure pumps to the accumulators supplying water to the rock drills. There are five of these pumps, the first four being operated by the two 250-HP. turbines and the fifth by the 600-HP. turbine. The transmission shafting from the turbines to the pumps is so designed that any one of the ten pumps can be thrown out of connection at will. Drawings of one of the pressure pumps are shown by Fig. 6. As will be seen, they are geared directly to the water wheel shaft and are thrown into and out of connection by a sliding spur wheel on the pump shaft. Three of the pumps have plunger diameters of 48 mm. and 68 mm, with 660 mm. stroke and at 78 revolutions furnish 6 liters of water per second. The remaining two pumps have plunger diameters of 60 mm. and 85 mm., and a stroke of 1 m., and they discharge 12 liters of water per second at 65 revolutions. The highest pressure of water possible with these pumps is 120 atmospheres per square centimeter.

Fig. 3. View of Escape Valve on Cast-Iron Penstock from Gate House at Gondo.

The water for the pumps is taken from two sources. The first is an 8-in. pipe connection with the penstock, and the second is the Rovale torrent on the heights above the portals of the tunnel. Fig. 7 shows the weir in this torrent and gives a view down into the valley occupied by the works. The Rovale water is used for the pumps as long as the quantity supplied is sufficient, but in times of shortage recourse is had to the penstock supply. In both cases the water is cleaned of all sediment by being passed through filter beds before being delivered to the pumps.

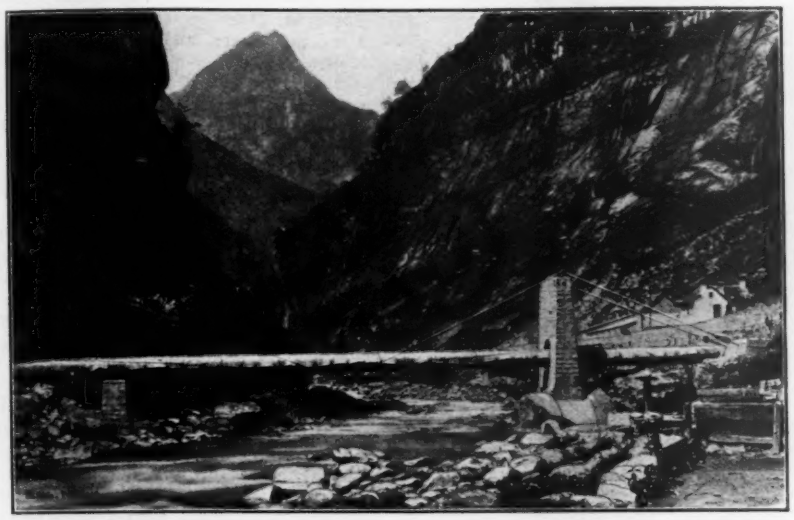


FIG. 4. VIEW SHOWING METHOD OF CARRYING PENSTOCK PIPE ACROSS THE DIVERIA BY SUSPENSION CABLES.

This battery of pumps is calculated for a capacity of 40 liters per second at a pressure of from 40 to 120 atmospheres (64 gallons per minute at 1,175 lbs. per sq. in.), but the present average supply, which suffices for the drills, injectors, etc., is 20 liters per second at 90 atmospheres per square centimeter. It may be mentioned here that the quantity of water used in such drill cylinder is one liter per second, and as there are two cylinders to each boring head, and three heads for each point of advance, and never more than three points of advance, we have $1 \times 2 \times 3 \times 3 =$ 18 liters required for three headings. With a pressure at the accumulators of from 80 to 100 atmospheres the pressure at the drills, 6 kilometers distant, is from 60 to 80 atmospheres. The pressure pipe to the drills is 100 mm. in diameter, with a shell 4 mm. thick, and was tested before installation up to 250 atmospheres. This pipe was supplied by the Mannesmann Tube Works, of Remscheid, Germany.

In the same room with the pumps are two air compressors. One of these is a duplex Burckhardt compressor, with a capacity of 2 cu. m. of free air per minute, built by the Maschinenfabrik Burckhardt, of Basle, Switzerland, and the other is an Ingersoll-Sergeant compressor with a capacity of 3 cu. m. of free air per minute, built by the Ingersoll-Sergeant Rock Drill Co., of New York city. These two compressors pump to a receiver consisting of Mannesmann tubes in rows inclined in the form of a V above a cement-lined pit to allow of their drainage. The pressure carried is from 70 to 80 atmospheres per sq. cm. From the receiver the air is piped to various points about the works and into the tunnel to about the fifth kilometer to supply the compressed air locomotives.

Besides the three water wheels in the main power house the water power described supplies two turbines in the ventilator house and one in the lighting plant. The maximum power supplied and its distribution is about as follows: For high pressure pumps, 700 HP.; for air compressors, 400 HP.; for ventilation, 500 HP.; for illumination, 100 HP.; for shop machines, 100 HP.; total, 1,800 HP. It is expected that as the work progresses another large turbine and additional high pressure pumps will be installed.

Besides the hydraulic power plant described above there is at the Italian end a supplementary steam power plant available as a reserve source of power. This plant is located in a building joining the main power house and consists of three compound engines, two of 80 HP. each and one of 60 HP. These engines were supplied by Rudolf Wulff, of Madgiburg, and are shown by Fig. 8. As will be seen, the engine and boiler in each case are combined on a single bed plate. These machines were transportel to the works over the high roads, using 40 and 50 horse teams.

VENTILATION.

For ventilating the tunnel during construction and after it is put in operation a permanent ventilating plant has been installed at each end. The ventilating machinery at each end consists of two 200-HP. turbines running at 400 r. p. m. and driving two fans 3.75 m. (12.3 ft.) in diameter. The turbines were supplied by Escher, Wyss & Co., and the fans by Sulzer Bros., of Winterthur. This machinery is arranged differently at the two ends. At the Swiss end the fans are placed one above the other close to the portal, and the air passage is carried across the roof of the tunnel, as shown by Fig. 9. At the Italian end the fans are arranged one behind the other and some distance away in a ventilator house, from which an air passage leads to the tunnel, as shown by Figs. 10 and 11. The ventilators at each end will furnish 50 cu. m. of air per second at a gage pressure of 250 mm. of water when running in parallel, and 25 cu. m. of air at a pressure of 500 mm. of water when running in series in a tunnel 10 kilos. long and 8 sq. m. sectional area.

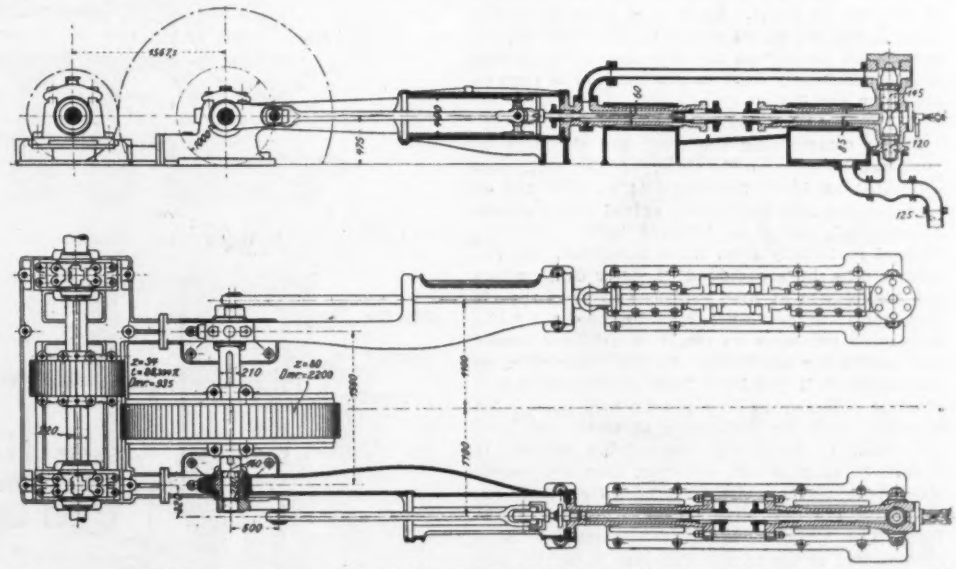


FIG. 6. PLAN AND SECTIONAL ELEVATION OF PRESSURE PUMP FOR SUPPLYING WATER TO ROCK DRILLS. Sulzer Bros., Winterthur, Switzerland, Builders.

Turning to Fig. 10, it will be seen that the air passage from the ventilator house bifurcates near its tunnel end and one fork goes to each tunnel. A door at the angle of the bifurcation closes either fork of the passage at will. Sail cloth curtains close the portals of the tunnel, and are operated either by hand or by electric motors. It will readily be seen from the plans that the air can be circulated either in Tunnel I. or Tunnel II., as desired; its movement being accomplished either by compression or aspiration. The foregoing remarks have referred to the ventilation of the tunnel after completion. To ventilate the workings during construction there is a branch from the air passage, Fig. 10, to the service gallery opened up along the line of Tunnel II. If the ventilation is by compression the air passes along gallery II. to the last cross-passage, through this, and then back along Tunnel I., as shown by the arrows in the sketch Fig. 12. If the ventilation is by aspiration then, of course, the flow of the air current is in the opposite direction.

At this point it may be well to note in explanation of Fig. 12 that it shows diagrammatically the condition of work from the Italian end in July, 1902. At this time the working face of Tunnel I. was some 500 m. (1,640 ft.) ahead of that of Tunnel II., owing to the fact that work had been stopped in the latter passage by treacherous material at meter 4,490. To pass this material, side passage No. 22 had been bored and excavation from it back to the treacherous material had been begun. This work will be referred to in more detail in a succeeding article, but its importance at this point lies in the fact that it interrupted the route of air circulation described above. Consequently a small fan was placed at cross-passage 21 B and forced air through a 14-in. pipe to the working force of Tunnel I. In conclusion it should perhaps be noted that all side passages are sealed up as the work advances to prevent short circuiting of the air current.

The various methods of operating the main fans may be explained by the aid of Fig. 11. To work the fans simultaneously and in parallel the doors A A are opened and the doors B B are closed, and the gates C C are also opened. To run the fans in series for compression the two forward side doors A A are closed and the doors B B are opened. To circulate the air by exhaustion with fans working in parallel the doors A A and B B are closed and the doors D D are opened; and to circulate the air by exhaustion in series the gates C C are closed and the doors B B are closed. Finally, the fans can be run singly and alone in either direction by suitably operating the gates C C, which have lever handles in the turbine room for that purpose. There are also in the turbine room a full set of recording gages indicating the pressure of air in the tunnel.

At present the ventilating potential of the plant is much in excess of the actual needs. One fan

operating so as to give a gage pressure of 60 mm. of water gives 1 cu. m. of fresh air per second at the working face. This circulation causes no unpleasant draft, but by increasing the gage pressure to 100 mm. of water the miners' lamps used by the workmen are blown out. The turbines and fans are worked alternately and 12 hrs. each. It is customary to lay the dust and to refreshen

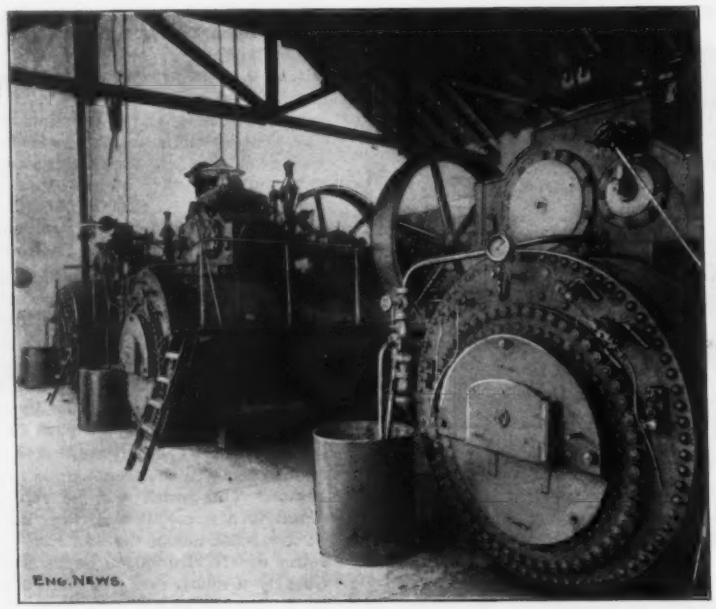


FIG. 8. SUPPLEMENTARY STEAM POWER PLANT AT ITALIAN END OF TUNNEL.

the air entering the fans by occasionally flooding the sides of the passages with water. The penstock for the ventilator turbines is a branch from the main penstock near the two deck service bridges previously mentioned.

Previous to the installation of the hydraulic plant a steam ventilating plant was installed at a point near the main ventilator house. This consisted of a 10-HP. engine running a fan delivering air through Tunnel II. by a pipe 50 cm. in diameter. At 1,200 r. p. m. this fan furnished 2 cu. m. of air per second with a gage pressure of 10 mm. of water. In case of accident to the main plant this small steam plant would supply enough air to prevent the stoppage of work, and it is consequently kept in readiness as a reserve plant for ventilation.

AIR REFRIGERATION.

Before commencing the work the elevation of temperature due to the heat of the rock was estimated as 1° C. for every 44 m. (144 ft.) of subterranean advance, but the actual temperatures encountered, owing to different influences, have differed materially from those estimated. At the Italian side the great flood of water coming into the tunnel was at first sufficient to keep the air cool, but as the work progressed beyond the leaks it became necessary to resort to artificial means for cooling the workings. At the Swiss side, on the contrary, it has been from the first a matter of some difficulty to keep the air cool enough for comfort, since the infiltration of water has been too small to have any appreciable effect. It should be emphasized, however, that the excessive temperatures which have been frequently recorded in the newspapers have no substance in fact. The highest temperature which has been encountered in the tunnel workings is 55° C., and was encountered during the autumn of 1902 at about the 8th kilometer from the Swiss end. As work progresses the temperature appears to be gradually decreasing.

The method of refrigerating the air is practically the same at both ends; cold water is forced into the headings and there broken into spray. At the Swiss end the refrigerating water is pumped from the River Rhone and forced through a 10-in. pipe laid along one side of Tunnel No. II. This pipe is insulated by jacketing it with a pipe 15¾ ins. in diameter and filling the annular space with charcoal. With this insulation the rise in temperature due to the passage of water through 9 kilometers of pipe is only 3° C. Fig. 13 is a transverse section of Tunnel No. II., showing the location of the refrigerating water pipe and also that of the high pressure pipes supplying water to the rotary drills. At the Italian end the cooling water is taken from one of the springs encountered in the tunnel. The sketch plan Fig. 14 shows the manner in which this task was accomplished. The spring which is utilized was the one which broke into transverse passage No. 21 A, Fig. 12.

ILLUMINATION.

For lighting the interior of the tunnel gas is used at the north end, while at the south end, far from any gas works, each miner carries his own oil lamp. To the American engineer this crude method of lighting is a matter of some surprise, considering the necessity for ventilation and the fact that there is an electric light plant at each end for lighting the buildings and yards. At the Italian end the central station is located near the main power house. There are here two generators, one supplying power to 32 500-c. p. arc lamps for lighting the yards and one supplying 300 incandescent lamps of 10, 16 and 32 c. p. These generators were supplied by J. J. Rieter & Co., of Winterthur, Switzerland, and are run by a 110-HP. turbine supplied by the Societe de Constructions Mecaniques, of Vevey, Switzerland. There is also a reserve dynamo operated by shafting from the reserve steam power plant previously described. This is a 16-KW. dynamo supplied by the Compagnie de l'Industrie Electrique of Secheron, near Geneva, and it supplies ten 500-c. p. arc lamps and 100 16-c. p. incandescent lamps.

DRAINAGE.

The drainage of the tunnel works is effected by gravity, excepting for a length of 500 m. in the center of the tunnel. At the Swiss end the fall is 0.2% for 9,184 m., and at the Italian end it is 0.7% for 10,086 m. The flow of water measured at the Swiss end at the last of October, 1902, was only 2,400 liters per minute, and at the Italian end it was 62,940 liters per minute, with a temperature in summer of 12° C. At the Swiss end the water passes into a special drain excavated in the floor of Tunnel II., but at the Italian end the whole floor of this passageway is submerged by the flood of outgoing water. Without this auxiliary passage having been excavated construction at the Italian end would have been very difficult, if not impossible. Indeed, the engineers for this end of the work are frank in stating that they consider that for any mountain tunnel of importance, say over six miles in length, this method of parallel tunnel construction is advisable for several reasons.

Almost all of the water at the Italian end is encountered between meters 4,000 and 4,600. In this distance several fissures discharge streams varying from 5 liters per second to 425 liters per second. The largest of these is an upright elliptical fissure about 4 ft. above the floor of the cross-passage 21 B, Fig. 12, and the amount of flow from it is 13,500 liters per minute.

WORKSHOPS.

The main machine shops for the repairs of rock drills and other machines requiring accurate work

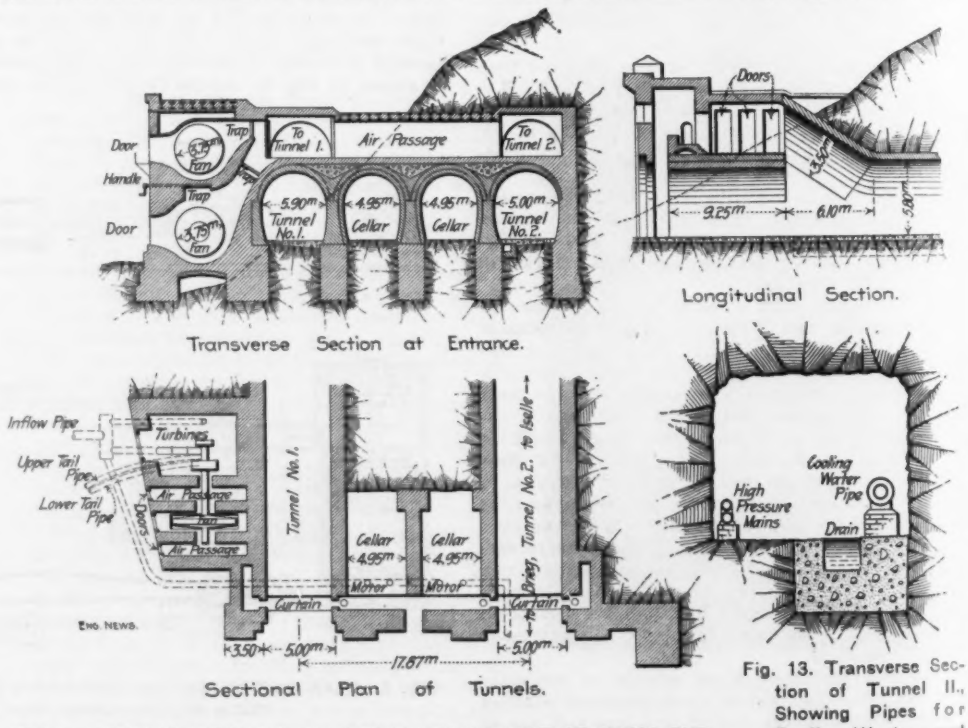


FIG. 9. DIAGRAM SECTIONS OF VENTILATION PLANT AT SWISS END OF TUNNEL.

Fig. 13. Transverse Section of Tunnel II., Showing Pipes for Cooling Water and Water for Drills.

are built in line with and adjoining the power station. The machine tool equipment consists of seven lathes, seven milling machines, three drills, two cold metal saws, two screw milling machines, and a planer, a punch and a plate shear, all operated by a small turbine with a small stationary steam engine held in reserve. In addition to these general tools, one end of the shop is

equipped with two testing stalls for the Brandt rotary drills employed in the tunnel. In these stalls the drills are mounted and tested on blocks of rock.

Detached from the main building are a number of smaller shops for various purposes. The first of these is used for erecting the heavy steel and timber bracing frames employed in certain porgencies. The larger or main filter is built of reinforced cement and is roofed over. It is 10.8 m. (35.4 ft.) long, 5.3 m. (17.4 ft.) wide and 3.6 m. (11.8 ft.) deep, with a bed formed of gravel and superimposed layers of clean washed sand.

There are bath houses for the workmen and engineers. That for the workmen is a building 37 m. (121.4 ft.) long and 13 m. (42.6 ft.) wide, and nel workings. The arrival is by the bridge shown at the left in Fig. 17, and in more detail by Fig. 19. As will be seen, this bridge is roofed over and boarded in to prevent a too brusque transition from the heat of the tunnel to the cold outside air. At the left end of the bridge is shown the torrent of water flowing from the tunnel workings. The workmen's bath rooms, 80 in number,

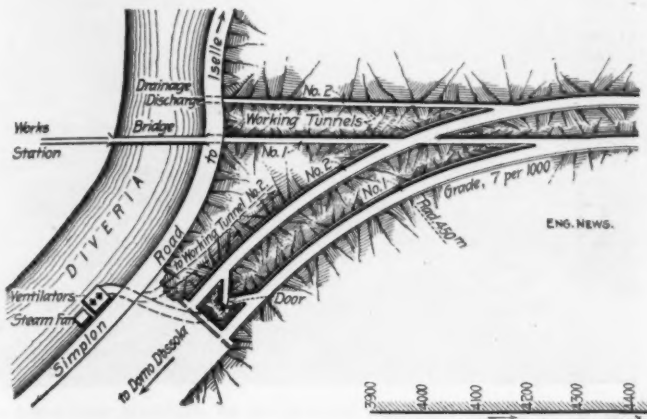


FIG. 10. SKETCH PLAN SHOWING PASSAGES FOR DELIVERING AIR FROM FANS TO TUNNEL AT THE ITALIAN END.

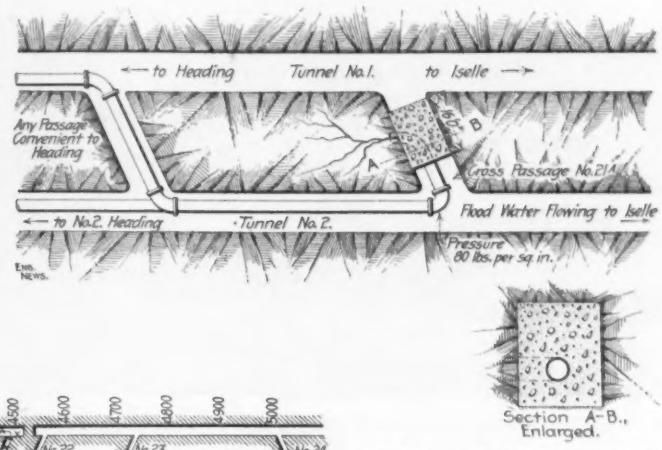


FIG. 14. SKETCH PLAN SHOWING METHOD OF TAKING COOLING WATER FROM SPRING IN TUNNEL.

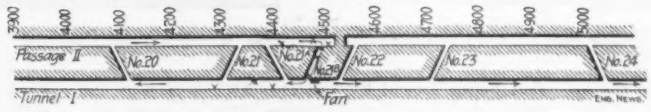


FIG. 12. DIAGRAM SHOWING CIRCULATION OF AIR IN TUNNEL.

tions of the tunnel, as will be described in a succeeding article. A woodworking and carpenter shop adjoins the frame erecting shop, the principal work done here consisting of repairs to the wooden spoil cars. The iron cars are also patched up here. Nearby is a locomotive roundhouse with stalls for four engines, track pits, filters, benches, etc.

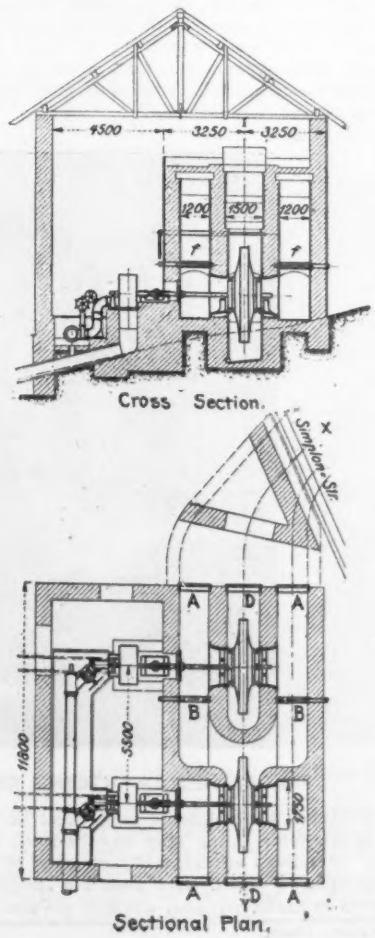
Further down the valley are sawmills and an extensive lumber yard. Here the dressed timber for special tunnel timbering is cut and stored. The consumption of wood in the tunnel is very great, and the logs from which it is cut are felled in the forests which cover the precipitous mountain sides above Iselle and transported to the sawmills by an aerial ropeway. The waste timber from the workings is used for fuel. Near the lumber yard there is a storage yard for the cut stone for the tunnel lining, and concrete blocks for the same purpose are made in a building located on the opposite bank of the river at the foot of the spoil bank of rock taken from the tunnel. The concrete blocks are, however, employed only in special cases, as their manufacture is more costly than the production of cut stone, the rough blocks for which are received from the spoil bank or from the quarries near Iselle, to which a track is built.

One of the most important buildings of the plant is the foundry and blacksmith shop, shown at the extreme left hand of Fig. 15. The foundry is equipped for founding the iron and bronze parts of the rock drills and such other small castings as are required in case of emergency. At the blacksmith shop the cutter heads and hand drills are sharpened. Fig. 16 shows a group of the cutting tools used in the tunnel, all of which have to be tempered and sharpented at the rate of several thousand a day. In this illustration the tools numbered are the following: (1) Countersink bit for starting the hole for the rotary drill; (2) Rotary drill head with cutter at one end and the other end threaded for connection with the lengthening bar. These cutters are sharpened repeatedly until worn down to a mere fragment; (3) Worn cutter head; (4) Hollow lengthening bar; (5) Bundle of hand drills or chisels.

BUILDINGS AND ACCESSORIES.

Besides the mechanical plant so far described, there are a number of minor structures which are deserving of mention. These will be briefly described without particular regard to location and importance. To supply pure water to the offices, workmen's dwellings and other places where potable water is required there are two filters, the smaller of which is held in reserve for emeris shown in the view Fig. 17, it being the flat roofed building with four roof ventilators. Here the men have their home attire, and can also bathe before changing into it from their working clothes. The soiled working clothes are stored in a special drying room, an interior view of which is shown by Fig. 18. The numerous cords here shown are carried over pulleys, and have at one end metal hooks and soap dish; the soiled garments are hung to these hooks and hauled up to the ceiling to dry. Each workman has his individual cord. At the left of the view is shown the door by which the men arrive from the tunare lighted by electricity and kept at a constant temperature of 22° C. by steam pipes. The engineers' bath house has about a dozen rooms with tub and shower baths.

Behind the baths are situated the two hot water boilers. Their location is shown by the chimney in Fig. 17. Here, too, are the laundries, fitted up with large barrel washing machines, centrifugal wringers, etc. These handle only the linen of the engineers and higher employees; the miners generally live with their families and have their work done at home. In the power house there is a small Linde ice-making plant. A number of habitations



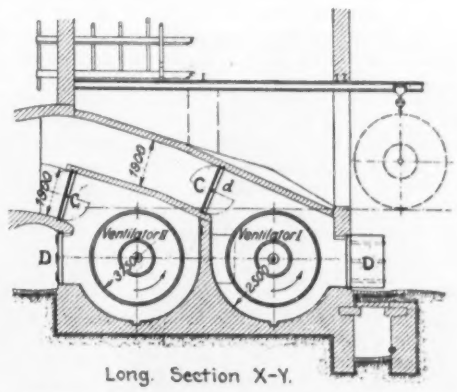


FIG. 11. DIAGRAM SECTIONS OF VENTILATING PLANT AT ITALIAN END OF TUNNEL.

for workmen have been erected on the works, but the greater number of these prefer to live in villages which have sprung up about Iselle and at the bottom of the Trasquera cliffs. This last village is called Balmelonesca and is shown by Fig. 20. Here on each side of the Simplon Road are the miners' cabins and two churches—one Catholic and the other Evangelical.

Owing to the rigid discipline enforced and to the natural prudence of the Italian workman, accidents are remarkably few. Full provision is, however, made at both ends of the tunnel to care for accidents. At the Italian end urgent cases and minor injuries are treated in a free dispensary located just at the entrance to the tunnel bridge, and where a surgeon and attendant are always stationed. The more serious accidents are treated in a hospital provided with 40 beds and in charge of a physician and two assistants. Here the miner pays 30 cts. a day for the care which he receives.

The miners are all insured by the company. Fig. 21 is a view showing the hospital building, with the engineers' village further back among the trees. Here the married engineers live with their families. A large boarding house, with club rooms and reading rooms, is provided for the unmarried engineers. Near this club house is a large three-story building, used for the constructors' offices, and higher up the valley, t near the ventilator house, is the two-story office building of the Jurn-Simplon Ry., Fig. 15. Herr Brandau, who directs the work at the Italian end, has a villa on the hillside above Iselle village. There are also a bonded storehouse and lodgings for customs guards and the police provided by the Italian Government.

FIG. 16. VIEW SHOWING DRILLING TOOLS USED IN TUNNEL WORK.

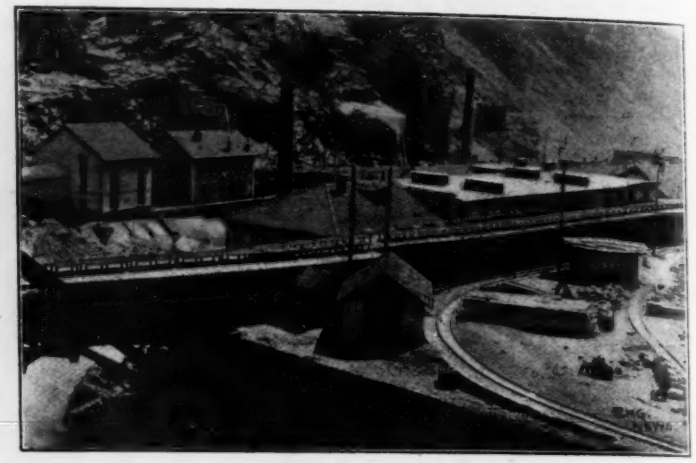


FIG. 17. VIEW OF PORTION OF WORKS AT ISELLE, SHOWING BATH HOUSES.

TRANSPORTATION SERVICE.

The transportation service is naturally one of the most important services connected with the tunnel work. The motive power used consists at both ends of steam locomotives, compressed air locomotivets and horses. The steam locomotives, of which four are employed at each end, are small six-wheeled four-coupled engines, with 24⅜-in. drivers and 10 × 11¾-in. cylinders, carrying about 12 tons on drivers. Fig. 22 is a view of one of these engines at the Swiss end of the tunnel. The smokestack is hinged, and the engine has no steam dome. The fuel burned is mixed coal and coke and is practically smokeless. Three compressed air locomotives are also employed at each end of the tunnel, and one otf these, at the Italian end, is shown by Fig. 23. These have 27 tubular reservoirs, with a capacity of 2,000 liters, carrying a pressure of 70 atmospheres per square centimeter, which is reduced to 15 atmospheres before entering the cylinder. The single cylinder, 125 × 150 mm., is placed horizontally between the frames and drives the forward axle through gearing with a reduction of 1 to 3.25. The driving wheels are 620 mm. in diameter, and the total weight available for adhesion is 6,500 kgs. To replenish the hot water reservoir there is a steam boiler in the tunnel or hose connection is made with one of the steam locomotive boilers. All steam and air locomotives were furnished by the Locomotiven Maschinenfabrik of Winterthur, Switzerland.

The service railway has a gage of 80 cm., with rails weighing 15 kgs. and 20 kgs. per miter laid on pressed steel ties. There are three types of spoil cars, narrow ones of wood 1.4 (4.6 ft.) wide for the buildings, worked by horses, large dump cars and flat cars for masonry. The dump and bat cars are 1.8 m. (5.9 ft.) wide, and the dump cars have a capacity of 1.6 cu. m. These cars are run in trains of from 4 to 14 cars, according to the needs of the work. They were furnished by Arthur Koppel, of Bochteim, Germany. The passenger cars are mounted on spiral springs and carry 24 men each; they are run in trains of 18 cars.

At the Italian end of the tunnel the transportation service is through Tunnel I., since Tunnel II. is occupied for the drainage of the tunnel. The steam locomotives work up to 4,400 m. (14,435 ft.), and from this point the air locomotives work to feet being served by horses. At the Italian end there are from 26 to 32 trains daily operated on a regular time schedule.

DRAINAGE OF IRRIGATED LANDS.

By Ernest McCullough,* C. E.

A large area of country in the West is rapidly becoming worthless by reason of over-irrigation or carelessness in the control of the flow in main canals. This is in sections which spent immense sums only a few years ago to obtain irrigating water. The sage brush plain became a thickly-populated district and prosperous homes abounded. Then the farmers quit raising hops or fruit and went in for alfalfa, because the water increased. Finally, they put in surface ditches and raised hay until even larger ditches became useless and the land was abandoned. Or sometimes the rising water brought such quantities of alkali to the surface that within three years after the irrigating ditch was brought in the land was white and nothing could be raised.

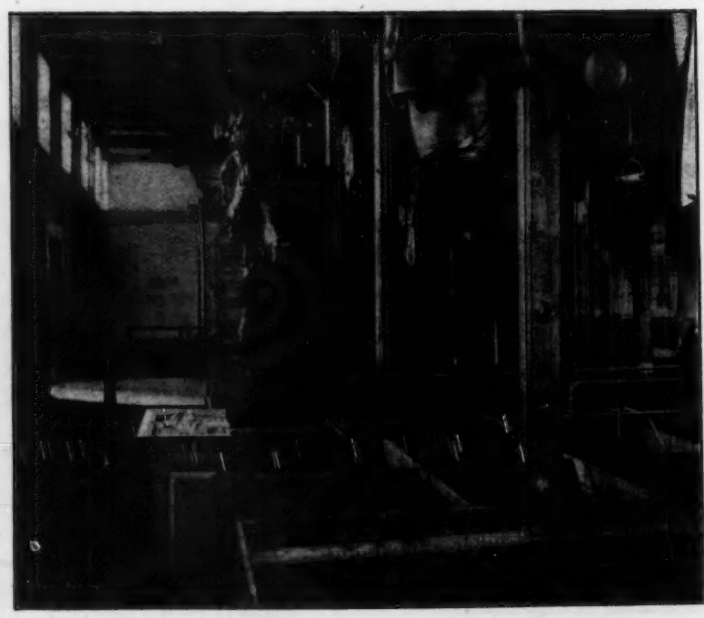


FIG. 18. VIEW OF INTERIOR OF GARMENT DRYING ROOM AT ISELLE.

The ditches have done a great deal of good, but in low-lying lands they have worked much harm. Hundreds of thousands of acres of land, photographs of which were used for advertising purposes in many sections, are now covered with

*Lewiston, Idaho.

tules, and boats and rafts convey hunters over once prosperous fields to the deserted homes, which they use for shooting boxes. The real estate agent hustles prospective buyers quickly past such places. This is no fancy sketch, and names of localities could be given were it pertinent. The curious, seeking information, can procure it from the officials connected with the Irrigation Investigations, Department of Agriculture, Washington, D. C.

In places where drainage has been tried oftentimes surprising results have been observed. It will be the endeavor of the writer in this article to show how drainage practice varies in the West from accepted practice in the East, and why.

There is a magnesium carbonate or a calcareous magnesium carbonate soil in the West strongly alkaline. It is found at depths of several feet below the surface, and when dry is almost as hard as rock. It dulls picks fast to work in it. If the least bit moist it spades out like firm butter or soft cheese. Exposed to the sun and air a few days on the bank of the ditch it becomes dry and powdery. In the language of the rancher, it "evaporates." In this state it resembles baking powder in appearance and touch, and is jocosely referred to as baking powder. But down in the ground in its natural state, when dry and hard, it is a most exasperating hardpan.

There is another hardpan, black as coal, almost, which on analysis seems to be decayed vegetation; a loam, in fact, but impregnated with alkali. Picks ring on it and plows do not go through it. It runs in ribs or "bones," generally parallel with the course of the main stream or river in the dis-

trict. It is this material which during the irrigation season causes water to run in channels in the soil and makes some fields marshy in places and all right in others. Once the alkali is dissolved the soil softens readily. It is not found close to the surface.

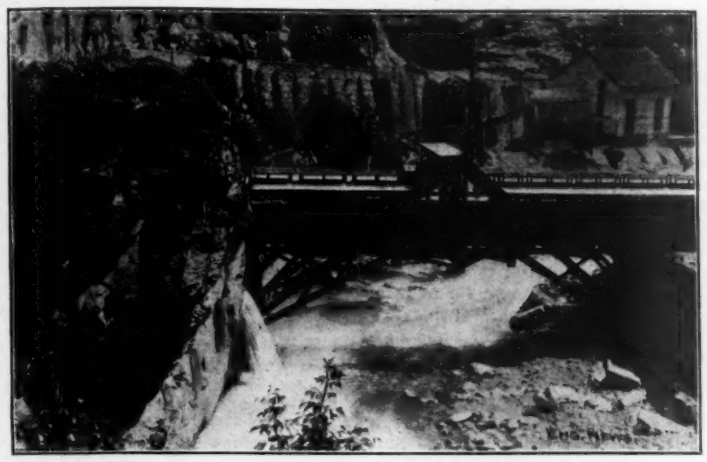


FIG. 19. VIEW SHOWING COVERED BRIDGE TO WORKING ENTRANCE AT ISELLE.

These soils are by the farmer called "alkali." They are to him the visible evidence of that group of compounds called alkalies that have the property of neutralizing acids. Tell him that the name is only applied properly to such members of the group as are soluble in water and he will wearily wave his hand towards the white crusted field and say, "I'm from Missouri. You've got to show me."

The average farmer or rancher has found upon digging drainage ditches through his alkali impregnated soil that a coating of salty slime forms on the sides and bottom of the ditch. This, of course, is the precipitation from the saturated alkaline solution suddenly exposed to the dry air and heat when much of the moisture is evaporated and the alkali in solution is dropped. This is too simple an explanation for the harassed farmer. He cannot be made to see that the stuff combines with the water and remains when the water leaves it. To him alkali is tangible, and is a sort of poison having cementing qualities of an extraordinary nature. He knows that the slime gradually interferes with the usefulness of his drainage ditches. He knows that while his fields show an excessive amount of moisture his drainage ditches are nearly dry. Then he takes a shovel and cleans an inch or so of material from the bottom and sides of his ditches, and they begin to flow well, while the moist spots in the field disappear.

We know the alkali is in the soil and the rising of the water brings it to the surface, there to remain when the water has evaporated or run off. This has been told the farmer, and he must believe because it has happened before his eyes. The Agricultural Experiment stations have made experiments and printed tracts to prove that drainage will help alkali land. Many farmers have tried tile drainage at considerable expense, only to give it up when the drains failed to work and they found the drains to be full of hard, dry silt and joints filled with salty "alkali." Having observed the action on the open ditches, they willingly accept the dictum of the wiseacres that in alkali the world possesses a wonderful hydraulic cement.

Water is turned on in the ditches about April 1. Land in which holes 5 ft. deep have been dug in perfectly dry soil about that date will begin to show water in the bottoms of the holes about May 1. On July 1 the whole field will be so boggy that wagons will stick, and sometimes may be left there while the horses wallow out. In September the ground begins to get firm, and about January 1 the ground water will have again dropped to the 5-ft. level. Such a state of affairs exists, say one or two years after the farmer begins to notice the rise in the ground water. This is the summer he begins to talk with his friends and with "experts." If he does not commence to drain, the chances are he will abandon the place in two or three years more. It will be seen that the drainage engineer has not only to drain the land, but he must contend against an annual rise which is concentrated into a short period of six to eight weeks. He must contend against the man who has read books written by men who drained in England and in Illinois; against men who have theories of alkali; against men who have tried and failed; against men who have a system all their own; against men who have ideas on general principles, and, last but not least, against the impression that drainage will "take the goodness from the soil." This is at the bottom of the opposition to drainage in irrigated sections, though men will but shamefacedly admit it. It seems the proud idea of the Westerner that "conditions are different here." The writer was reared and educated and had all his experience in the West and knows the existing feeling. Drainage may not do harm in the East, but may in the irrigated sections of the West—according to the local oracle.

Provide drains capable of taking care of 1 in of rainfall in 24 hours. That is the accepted rule in the Middle and Eastern states. In the West we must provide for a 5-ft. rise in six or eight weeks, and that during the irrigating season. We must give a depth of not less than 4 ft., and must put our drains at such frequent intervals that no appreciable amount of "wetness" is observable. The farmer wants absolutely no sub-irrigation from his neighbors, but the water received by his plants he wants to apply himself, on the surface, at their roots. We must figure that as the surrounding country becomes waterlogged this 5-ft. rise may now and then come in three or four weeks. There are men naturally wasteful in the use of water who will become more so when their neighbors provide outlets. All these things must be taken into account in proportioning the mains. As the necessity arises, laterals can be put in between the older ones, and ultimately any amount of water taken care of.

The people have an easy optimism. They say that in time the ditches will silt up and there will be less loss from seepage. They even say such things in a section where the soil is gravelly and porous, and where the ditches run bank full two weeks after water has been shut off at the headgates. To the writer it looks as if the irrigation canals for a short time reversed operations and acted as drainage ditches. If this is so, when will they silt up?

Running through the soil in all directions are circular channels coated with calcareous carbonate. They vary from ¼ to 6 ins. in diameter. They may be old root channels or old prairie dog holes. But as they are generally coated, it may be the geologist who will have to explain them. Seepage water percolating through the soil strikes some of these pipes and follows them. The first intimation of danger the farmer receives is striking one some day with his plow and developing what he calls an "artesian well." The writer had noticed the phenomena many times.

So the farmer in the irrigated section may expect his water to come from below, owing to a rise in the general water level of the country. This gradual annual rise will ruin the whole section unless it is prevented. He may expect to be sub-irrigated by his neighbors, who use water extravagantly, and this water comes in regular channels: (1) between "bones" of hardpan or (2) in little tubes through the earth. This sub-irrigation may come for miles. Any method which does not provide a way to take good care of it during the six or eight weeks of the irrigating season, when the water is applied most plentifully, is useless. The drains must run all the time then. The underdrainage will take care of all the alkali ultimately. The effect of the underdrainage will be, here as elsewhere, a gradual disappearance of hardpan and a general mellowing of the soil.

Hard and fast rules as to grades of drains cannot be followed. The writer completed, the past year, the drainage of eighty acres of land which lay in the shape of a parallelogram half a

FIG. 22. VIEW OF STEAM LOCOMOTIVE AT SWISS END OF TUNNEL.

mile long from north to south and a quarter of a mile wide. All the mains had to deliver to the southwest corner into a main outlet. From the southwest corner the land fell 1 ft. in a distance of 1,320 ft. north, then was level for 1,000 ft., and rose 18 ins. in 320 ft. The rise from the northwest to the northeast corner was 1 ft. From the northeast corner south it was perfectly level for 1,320 ft., then in the next 1,320 ft. to the southeast corner it rose 30 ins. It was smoothed off perfectly and looked level. The main outlet for all the drains was half a mile long, this being the distance necessary to go to get rid of the water. It had to be taken under an irrigation waste ditch 10 ft. wide and 4 ft. deep, and across (in a pipe) a country road 80 ft. wide.

A great lack in Western states is a good drainage law. The ditch companies and wasteful irrigators causing the drainage can be easily identified, but so far no sensible relief has been proposed.

The ordinary tile drain has proved successful in few places. The reason is the very fine silt introduced into the drains with the alkali laden water. I know of nothing tangible to compare it with for exceeding fineness, except copper sulphate found in smelter flues. But it is composed of the oxides of calcium, barium and strontium, is exceedingly heavy, and inclined to cement.

The writer shared the belief of many engineers that a careless laying of tiles might account for much of the stoppage. But he laid some himself where half a cent a foot extra was paid to get trimmed ends. There was no water encountered during the work, and the grades were as near perfect as grades could be. But alas! some of the ditch was in the magnesium carbonate, and when the water came in the stuff fairly melted and flowed in, so the grade and alinement did not last long. In other places no harm was experienced in that way, but the silt got in through cracks as fine as it was possible to make them. When the irrigating season is on and square miles of territory are flooded for alfalfa the water goes into the drains under pressure. Every farmer cannot afford to hire an experienced drain-layer, and not all who claim to know have had experience. What is wanted is a form of drain any man can lay without paying too much attention to grade and alinement.

The farmer prefers to use wood and replace it in ten or twelve years rather than to have to dig up and relay earthen tiles every second or third year. The first cost, both for material and for labor, is a little higher in the case of wood.

Laterals are generally made of 2 × 6-in. tops, with 1¼ × 6-in. sides, thus giving an inside channel 6 ins. deep by 3½ ins. wide. Owing to surfacing one side and edge the exact inside dimensions are more nearly 5¾ × 3¾ ins. The surface side is inside. The boxes have no bottom, but the sides are tied at each end and sometimes also in the middle by a 6-in. piece nailed across. This gives a firm bearing on the bottom of the trench, preventing the edges from being pressed in when the ground gets wet. It also tends to keep the earth pressure from pushing in the sides. Without these ties, boxes in soft earth sometimes have the sides touching at the bottom. The tie at one end projects about an inch to receive the end of the next box, the tie at the other end being set back about an inch and a half.

The lengths of the boxes are governed by the alinement of the trenches. In a straight trench boxes 10 or 12 ft. long can be laid and thus save material, nails, and labor in sawing. Boxes 4 ft. long are most easily handled. The ends are laid as closely together as possible, and a couple of thicknesses of burlap placed over each side and top. The intention is to allow water to come in only at the bottom. The silt has no opportunity to settle, but is continually stirred and must float. The grades being so slight, there is small danger of a scouring velocity tending to wash the bottom enough to disturb grade and alinement.

For sub-mains 6-in. sides are used, while the tops may be 2 × 8, 2 × 10 or 2 × 12 ins. If any greater depth is used then the sides as well are 2 ins. Thus we put in some sub-mains with 2 × 12-in. tops and 2 × 10-in. sides, giving channels 10 ins. deep and 8 ins. wide.

Laterals are connected to mains and sub-mains by simply sawing a piece out of the top clear across and wide enough for a lateral to fit in. One end of a lateral box is covered and a piece put on the bottom, except at that end an opening is left in length equal to the width of the main. These two openings are fitted together, some burlap or waste packed around the cracks, dirt shoveled in, and the connection is made. It is hardly necessary to state, after the above explanation, that as all connections are made on top the mains and sub-mains are deeper than the laterals by an amount equal to the depth of their sides.

Mains and sub-mains are joined, and all changes of direction made, in boxes about 4 ft. square, with wooden or gravel bottoms and hinged covers. The tops of the insides of the channels of all entering and discharging conduits are on the same level. The bottoms of the boxes are at least a foot below the bottom of the outlet to collect silt. The conduits have no bottoms, except for at least one length out from each silt box. If for any reason the owner feels he would prefer some subirrigation he can plug up with gunny sacks his conduits at the silt boxes and nail planks temporarily over the openings. In one piece of work the writer made a simple gate at the end of each lateral, so any portion of the water could be shut off when desirable.

The principal mains are not intended to do any, or much, draining, and are made of four planks nailed together at their edges: 2 × 12-in. planks give a conduit 10 × 10 ins. square, etc. These conduits are laid on one edge. At one end, two pieces of 1 × 6-in. stuff are nailed, projecting a few inches on the two lower sides to receive the end of the connecting section and thus preserve grade.

Some farmers say the tops rot first and make their drains of 2 × 10 in., and sometimes 2 × 12-in. planks. They are nailed together at one edge, and two make a drain. Across the opening are nailed tie pieces to keep them from spreading and also from sinking. The channel is thus triangular in cross-section with the point at the top.

Some slight measure of success with ordinary tile drains has been achieved by tarring or asphalting the ends and placing tarred paper or cloth around fully three-quarters the way. This allows water to enter only at the bottom. This, however, in some soils is not enough. The writer has dug up hundreds of drain tiles to observe the manner in which silt is deposited, and has found it follows a regular system. When his investigations are complete he hopes to publish the results with illustrations.

The farmer's idea of keeping the bottom stirred and the stuff moving is good. The result might be attained in ordinary drain tile by having ⅛-in. slit along one side and laying this as the bottom. Make the tile in any length up to 3 or 4 ft., and try to make the joints absolutely tight except on the bottom. This would be the least expensive special tile.

Another form would be a horseshoe-shaped tile, or egg-shaped, open along the bottom. Another form would be a square tile, open along one edge Makers of drain tile have given the writer absolutely no encouragement to believe that any other than the regular form will be made. The special forms they say will be too expensive.

There exists in the minds of some men in districts where tiling has been tried a prejudice so strong against it that it will be difficult to have any draining done. When it is done, ten chances to one wood will be used, although it requires a larger ditch and has to be sawed and nailed together. The labor item is thus increased.

Tiles are easier handled, require a smaller ditch, afford a better channel and are, of course, more durable than wood.

THE MANUFACTURE AND PROPERTIES OF NICKEL-STEEL.*

By Albert Ladd Colby,† M. Am. Soc. M. E.

My search through the proceedings of scientific societies for the past eighty years shows that the advantages of alloying nickel with iron and steel have been known and acknowledged by many investigators over a long period of years. Mr. James Riley was, however, the *first* to publish a series of practical experiments proving the valuable properties possessed by nickel-steel, and pointing out many of its important applications.

In 1822, Stodart and Faraday published their experiments made at Sheffield in the alloying of nickel and iron. A little later Berthier made some similar experiments in France. In 1830, Wolf, of Scheinfurt, Germany, put some nickel-iron alloys on the market, which he called "Meteoric Steels." They were damasked, and Liebig comments on their magnificent appearance in a note in the "Annalen der Pharmacie," and states that this alloy is destined to be developed in the near future. In 1853, Fairbairn published some experiments undertaken to determine the strength of some alloys of nickel and iron similar in composition to meteoric iron. At the Exposition, held in New York, in 1853, Philip Thurber exhibited several samples of nickel-steels produced from a nickeliferous limonite. In 1858, Sir Henry Bessemer made an experimental 3% nickel-iron alloy, with a view of making whatt he termed "Meteoric Iron Guns!" He did not, however, pursue the subject, nor publicly refer to the matter until 1896. Percy, in his "Metallurgy," published in 1864, refers to experiments conducted by Richardson in his (Percy's) laboratory on nickel-iron alloys varying from 1.00—50.00% in nickel. In 1870, Alex. Parkes, of Birmingham, took out several patents for the production of alloys of iron and steel. In 1883, John Gamgee made nickel-iron alloys in Connecticut. In 1884, A. M. Clark, of London, patented the manufacture of a malleable ferro-nickel. In 1885, ferro-nickel was manufactured at Marbeau's Works at Montataire, France, under the supervision of Bertheault. In 1887, highly carboniferous nickel-steels were made experimentally at the Steel Works at Imphy, France. In 1888 and 1889, several French and English patents for the manufacture of nickel-steel, and its applications, were granted to Marbeau, Schneider, Riley and Hall.

It is therefore evident that the advantages of alloying nickel with iron and steel have been known for some time. The credit of making the first systematic series of practical tests on nickel steels belongs, however, to Mr. James Riley, then of Glasgow, whose elaborate paper on "The Alloys of Nickel and Iron," was read by him before The Iron & Steel Institute of Great Britain, on May 8, 1889. From a discussion of this paper it appears that J. W. Hall, of Sheffield, had been working on similar lines to Mr. Riley, but his results had not been publicly put on record. Mr. Riley's paper gave the impetus to the introduction of nickel-steel in a commercial way. Since Riley's practical and suggestive paper, the technical men of many steel works in France, Germany, Great Britain and America, have made nickel-steel, studied its physical properties and have put it on trial for a wide variety of purposes. In this work they have been aided by consumers looking for a better material, by the scientists connected with the technical universities in each country, as well as other independent investigators.

MANUFACTURE OF NICKEL-STEEL.

No detailed reference to the melting of nickel-steel and its subsequent rolling, forging and machining is possible within the scope of this paper. As is well known nickel-steel is melted in both the acid and basic open-hearth furnace, in the Bessemer converter, and in the crucible. The physical constants of the metals, nickel and iron, are so closely allied, a fact proven by their occurrence in metallic meteorites, that no special precautions, other than those incident to good melting practice, are necessary during any of the above standard processes of steel melting, in order to insure a thorough mixture of the nickel and iron in the manufacture of nickel-steel of any desired percentage of carbon, and with or without the presence of special elements, such as chromium, manganese, tungsten, molybdenum, etc. This fact is of great practical importance, especially in such applications as armor plate, marine and stationary shafting, and engine forgings, rails and bridge material, which necessarily involve the casting of large masses of this special steel. Precautions must be taken in the rolling or forging of nickel-steels, and especially in their final heat treatment; the steels below 15% nickel are also more difficult to machine than simple steels of the same carbon content. These difficulties have however, formed no serious barrier to its successful introduction for a wide variety of purposes.

PHYSICAL PROPERTIES OF NICKEL-STEEL, AS COMPARED WITH CARBON-STEEL.

Physical properties of nickel-steel, as compared with those of carbon-steel, are better known and more fully appreciated, the amount now used for the purpose for which it has already been successfully introduced will be considerably augmented and new applications will undoubtedly result. It is appropriate, therefore, to review some of these more striking physical properties.

MODULUS OF ELASTICITY.—The modulus of elasticity or "coefficient of elasticity" of such materials as steel which have a well defined elastic limit, is determined by dividing the tensile stress in pounds per square inch at any point in the test below the elastic limit, by the elongation per inch of length produced by said stress. The modulus of elasticity which may therefore properly be regarded as the measure of the stiffness of the material is

*Abstract of a paper read before the American Society for Testing Materials.

†Bethlehem Steel Co., South Bethlehem, Pa.

remarkably constant in steel notwithstanding great variations in chemical analysis, temper, etc. Young's modulus is practically the same for both tool steel containing 1.40% carbon and for the mildest steel used in boilers. The modulus of elasticity of steel is in fact rarely found to be below 29,000,000, or above 31,000,000, and is generally taken at 29,500,000 or 30,000,000 in engineering calculations.

A prejudice exists against nickel-steel in the minds of some engineers owing to items which have appeared in the technical journals that the modulus of elasticity is lower in nickel-steel than in carbon-steel. The fact is, however, that while the high nickel-steels, especially those containing 20% nickel or over, do have a lower modulus of elasticity than carbon-steel, nickel-steels containing say 4% of nickel or less, such as are applicable for shafting, forgings, bridge construction, rails, etc., have the same modulus of elasticity as carbon steels, viz., in the neighborhood of 29,000,000 lbs. per sq. in.

In proof of this assertion, the writer could quote the result of many calculations of the modulus of elasticity of various steels, containing below 5% nickel, made from the detailed records of the physical tests published annually by the U. S. Army Testing Laboratory at Watertown, Mass., under charge of Mr. J. E. Howard, the accuracy of whose work is beyond question. Evidence could also be cited from the experiments of foreign scientists, such as Mercadier, Wedding, Rudeloff and Guillaume, all of whom support the above assertion that the presence of 4 or 5% of nickel in steel has no appreciable effect in reducing its modulus of elasticity.

TENSILE STRENGTH AND ELASTIC LIMIT.—If space would permit, a large amount of evidence could be cited to prove that nickel-steel is chiefly distinguished from simple carbon-steel by its proportionately high elastic limit. Furthermore, if 3% nickel is alloyed with an open-hearth steel of 0.25% carbon, it produces a metal equal in tensile strength to a simple carbon-steel of 0.45% carbon, but having the advantageous ductility of the lower carbon-steel.

On low carbon-steels not annealed, the addition of each 1% of nickel up to 5% causes approximately, an increase of 5,000 lbs. per sq. in. in the elastic limit, and 4,000 lbs. in the ultimate or tensile strength. The influence of nickel on the elastic limit and ultimate strength increases with the percentage of carbon present; high carbon nickel-steels showing a greater gain than low carbon nickel-steels.

In short, the addition of nickel to steel raises the proportion of elastic limit to ultimate strength and adds to the ductility of the steel. This effect of nickel in increasing the ratio of the elastic limit to tensile strength, without sacrifice in ductility, accounts for the increase in the working efficiency of nickel-steel over carbon-steel; in other words, its increased resistance to molecular fatigue.

ELONGATION AND CONTRACTION OF AREA.—The comparison of the results obtained from a large number of tests cut from full-sized prolongations of forgings of both carbon-steel and nickel-steel, show that for a given tensile strength the presence of 3 to 4% of nickel increases the elongation, and to a greater extent the contraction of area. On the other hand, comparing simple carbon-steel and 3 to 4% nickel-steel of the same carbon content, the nickel-steels will be found to have from 35 to 40% greater tensile strength with practically the same elongation and contraction of area as the simple carbon-steel. This increased ratio in the nickel-steel, of ductility to elastic limit and tensile strength, is another index of its increased value over carbon-steel and for purposes where in service the material must resist severe and sudden shocks or rapidly repeated alternating stresses.

EFFECT OF COMPRESSION.—The exhaustive series of experiments made by Wedding, and Rudeloff, show that the resistance to compression of nickel-iron alloys increases steadily with the per cent. of nickel present, until 16% of nickel is reached. Hatfield has also made a very complete series of experiments on the resistance of nickel-steel to compression. He has found that a steel containing 0.27% nickel shortened, under a compression of 100 tons (224,000 lbs.) per sq. in., 49.90% in a length of 1 inch; a steel with 3.82% nickel shortened 41.38%; with 5.81% nickel, 37.76%; and with 11.30% nickel, only 1.05%. He states that an ordinary mild carbon-steel without nickel, under similar conditions, would be shortened 60% to 65%. He also states that the increased resistance to compression of nickel-steel is not due to its hardness, an important point in the practicable application of nickel-steels where machinery is necessary. He argues that the toughening action of nickel when added to steel is caused by a very intimate combination of the molecular structure and that this advantage is further enhanced by the fact that the nickel does not show a disposition to segregate in steel like other elements; in other words, it appears to be more intimately combined.

A striking illustration of the ability of nickel-steel to resist compression was exhibited to the writer in 1900 by Holtzer & Co. A cylinder, 7.87 ins. in height, 6.87 ins. externad diameter and walls of 0.73-in. in thickness, cut from a nickel-steel gun hoop, was compressed by a load of 886 gross tons down to a height of 4.72 ins.; The internal fibers were thereby extended 46% and without the formation of any cracks.

RIGIDITY.—The superior stiffness of nickel-steel over carbon-steel without any sacrifice in its toughness has been proved in numerous applications coming under the writer's observation; this combination of properties forms one of the strongest arguments in favor of the use of nickel-steel for a wide variety of applications where the service demands a rigid, as well as a strong elastic and tough material. H. A. Wiggin states that, in his experience he found that nickel-steel under the drop test gives better results than carbon-steel, even in a greater ratio of superiority than exists in the comparison of the tensile tests of the two steels.

J. G. Eaton made a comparative test of nickel-steel plate and carbon-steel plate with a view of subjecting both plates to the same strains as those experienced by bottom plating. Both plates were riveted to angles in a manner intended to imitate the riveting of a ship's plate between the frames. A round-faced punch placed on each plate was then struck by a heavy falling weight. Each plate endured 13 blows before rupture and at the next blow each plate showed a clear aperture; that in the carbon-steel plate, however, was 23.1 sq. ins. in the clear, while the aperture in the nickel-steel plate was ¾-in.; a ratio, therefore, of 30.5 to 1, in favor of nickel-steel.

D. H. Brown states that a 3% nickel-steel shows about 48% greater stiffness and 45% greater toughness than carbon-steel; the word "stiffness" referring to the amount of deflection produced by the blow, while the word "toughness" refers to the number of blows required to produce the rupture.

COLD AND QUENCH BENDING TESTS.—Nickel-steel will resist bending both before and after quenching better than carbon-steel of similar tensile strength. This has been strikingly illustrated in a long series of practical tests made on nickel-steel plates by Mr. Beardmore at his Parkhead Steel Works, at Glasgow, Scotland. These tests included quench bends, cold bends, and also cold bending tests of the nickel-steel plates with holes drilled in the tests prior to the bending. The results of Hadfield's careful experiments on the bending properties of cast and forged nickel-iron alloys, varying from 0.27 to 49.6% of nickel, may be summarized in his statement "that from about 2.5 to about 6% nickel, the bars certainly showed greater bending angles than those of any other iron alloys experimented on," by him.

In a series of comparative tests of carbon-steel and nickel-steel, such as is used for forgings made at the works of the Bethlehem Steel Co., the writer obtained bending tests on the unannealed, annealed and oil-tempered nickel and carbon steels which show the superiority and freedom from brittleness of the nickel steel. A comparison of the physical properties of the two steels is as follows:

Heat treatment.	Lbs. per sq. in. Tensile strength.	Lbs. per sq. in. Elastic limit.	Elongation per cent. in 2 ins.	Contraction of area, %.
Annealed:				
Carbon-steel ..	109,500	51,440	19.50	30.31
Nickel-steel ...	100,330	66,720	25.00	54.50
Oil-tempered:				
Carbon-steel ..	129,360	67,230	17.50	38.53
Nickel-steel. ..	103.890	76,390	25.00	61.56

HARDNESS OF NICKEL-STEEL.—It has been definitely proved that a very low carbon-steel cannot be made hard by the mere addition of nickel. Nickel-steel is tougher than carbon-steel, but is not harder in the true meaning of this latter term. The hardness of nickel-steels below about 15% of nickel, depends upon the proportion of nickel and carbon jointly. Thus while a steel with 2% nickel and 0.90% carbon cannot be machined, a steel with 3% nickel and 0.60% carbon can be machined. The freedom from hardness of comparatively low carbon nickel-steel is strikingly illustrated by the writer's experience in cutting with a penknife the rifle barrels made at Bethlehem, of steel containing 4.50% nickel and 0.30% carbon, and yet this steel had an elastic limit of over 80,000 lbs. and a tensile strength of over 100,000 lbs. per sq. in. At 20% of nickel, as stated by Riley, successive increments of nickel tend to make the steel softer and more ductile, and even to neutralize the influence of carbon.

RESISTANCE TO TORSION.—Nickel-steel resists torsion or twisting stress better than the same class of carbon steels. Riley's experiments indicate that it is not necessary to use steels high in nickel to obtain the best effect in torsional resistance. The writer has found that several of the French steel works have appreciated this property of nickel-steel by applying it for the manufacture of special wire and springs.

RESISTANCE TO WEAR OR ABRASION.—The rigidity and toughness of nickel-steel makes it a desirable metal where, in service, the material is subjected to wear or abrasion. Practical evidence of this statement is found in the three years comparative trial of nickel-steel and carbon-steel rails on the "horse-shoe" curve of the Pennsylvania Railroad, which has recently resulted in orders being placed for some 10,000 tons of nickel-steel rails for the sections of the tracks of the Pennsylvania, Baltimore & Ohio, and New York Central & Hudson R. R., where in the past frequent renewals of the carbon-steel rails have shown their inability to withstand the severe abrasion due to the sharp curves and heavy traffic. Further evidence of the value of nickel-steel to withstand abrasion is found in the results of experiments carried on by one of the French railroads in the trial of nickel-steel for locomotive tires.

EXPANSION OF NICKEL-STEEL.—The coefficient of expansion of nickel-steel varies greatly with the percentage of nickel present; especially in the series of nickel-steels containing from 20 to 45% of nickel. The 36% nickel-steel called in France "Invar" (from the word "invariable") has a lower coefficient of expansion than any other metal or alloy known.

Guillaume, of the International Bureau of Weights and Measures, the best authority on this subject, and whose opinion is also supported by other experts, states, however, that there is no practical difference between the expansion of simple carbon-steel and of steel containing up to 5% of nickel. In the use, therefore, of low carbon, 3 to 5% nickel-steels in bridge construction the same allowance for expension can be made as when carbon-steel is used. This is an important point especially when both carbon-steel and nickel-steel are to be used in the same structure. The different coefficients of expansion of steels, containing from 30 to 45% of nickel, have resulted in their application in France and Germany for a wide variety of purposes.

EFFECT OF PUNCHING AND SHEARING ON NICKEL-STEEL.—Beardmore, the Scotch steel maker, after an elaborate series of tests, places the loss of strength due to punching ordinary mild steel at 33% of the original strength, and claims that the loss of strength in punching nickel-steel varies from 15.5 to 20% of the original strength and furthermore that on thicker sections of nickel-steel plates the loss of strength is only about 10%. A number of other experimenters have also found that nickel-steel plates are not weakened by punching to as great an extent as carbon-steel plates. There is ample evidence that the presence of nickel in steel increases its shearing strength. This is important especially in connection with riveted work, as the strain on the rivet is not a simple strain but rather a shearing or cutting action. Moreover in the shearing of nickel-steel rivets, the fracture is fibrous and the metal appears to have torn gradually, whereas in ordinary carbon-steel rivets the metal breaks off short.

From the results of a comparative test made at Bethlehem on nickel-steel and carbon-steel rivets, the conclusion was drawn that "it may be safely deduced that a ¾-in. nickel-steel rivet will replace a 1 1-16-in. or even possibly a 1⅛-in. common steel rivet, thus effecting a saving of considerable plate section and giving increased strength." Experiments made by Beardmore, Abraham and Rudeloff and at the Creusot Steel Works, also testify to the increased shearing strength of nickel-steel rivets. Experiments made by the Societe Denain and d'Anzin prove that 5% nickel-steel rivets possess over twice the shearing strength of iron rivets. Browne states that the sheared edges of carbon-steel plates often cut ragged whereas nickel-steel cuts clean.

SEGREGATION.—The writer's opinion, based upon a large number of chemical analyses made at Bethlehem, is that nickel in itself segregates but very slightly even in large armor plates and shafting ingots. This is natural as the atomic volume, atomic weight and specific gravity of nickel are similar to those of iron.

Some experimenters testify that nickel tends to check the segregation in steel of the other elements such as sulphur, phosphorus, carbon, manganese and silicon. Mr. Hadfield thinks that the tendency of nickel to check segregation is probably due to the fact that it raises the melting point of the carbides or cementing material and causes the whole mass to set more nearly together, and quotes in proof that nickel-steel ingots have a finer grain than carbon-steel ingots. Mr. Chase, of the Midvale Steel Co., states that "nickel is supposed to lessen the segregation and liquation of carbon by combining with the carbon which cements the particles of iron together, and thus bring the specific gravity of the carbon compounds nearer to that of the rest of the alloys in the fluid mixture. It also seems to cause this cementing carbon to solidify at more nearly the same temperature as the other alloys."

Mr. Campbell, of the Pennsylvania Steel Co., made a series of tests to prove what he states to be the current impression among manufacturers of nickel-steel, that the presence of this element prevents segregation. His conclusion is that there seems to be good ground for the assumption that nickel prevents the separation of the metalloids, but that it does not prevent it altogether, and he states that it is probable that any other agent will ever be found competent for this task.

Within the limits of this general review, it is impossible to refer in detail to the interesting subjects of the heat treatment, the critical points, the molecular relation of nickel to iron and carbon and the microstructure of nickel-steels; the effect of extreme temperatures and the electrical and magnetic properties particularly of steels containing over 20% of nickel.

Sufficient evidence has, however, probably been presented to prove that nickel-steel possesses many advantages of practical importance over simple carbon steels, and the engineer looking for a trustworthy material will be convinced by what has been presented, that it is safe to give nickel-steel a practical trial.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering.

Entered at the New York Post-Office as Second-Class Matter.
Published every Thursday
at St. Paul Building, 220 Broadway, New York, by
THE ENGINEERING NEWS PUBLISHING COMPANY

GEO. H. FROST, - - - - - - - - - PRESIDENT.
D. McN. STAUFFER, - - - - - - - VICE-PRESIDENT.
CHARLES WHITING BAKER, - - - - MANAGING EDITOR.
F. P. BURT, - - - - - - - - - BUSINESS MANAGER.

M. N. BAKER, CHAS. S. HILL, - - - } ASSOCIATE EDITORS.
E. E. R. TRATMAN, F. E. SCHMITT, - - - }
WM. KENT, H. P. GILLETTE, - - - - }

CHAS. W. REINHARDT, - - - - - CHIEF DRAFTSMAN.

ALFRED E. KORNFELD, New York, }
M. C. ROBBINS, Chicago, } ADVERTISING REPRESENTATIVES.
S. B. READ, Boston, }

PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 170 SUMMER ST.

FOREIGN AGENTS.

C. MITCHELL & Co, Snow Hill, Holborn Viaduct, LONDON.
RUDOLF MOSSE, BERLIN and HAMBURG, GERMANY.
JOHN F. JONES, & CIE., 31 Rue de Faubourg Montmartre, PARIS.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 months, $2.50; 10 weeks, $1.00. To all other countries in the Postal Union: Regular Edition, One Year, $8.00; Thin Paper Edition, One Year, $6.75. SINGLE COPIES of any number in current Volume, 15 cents.

In requesting change of mailing address, state BOTH old and new address; notice of change should reach us by Tuesday to be effective for the issue of the current week. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 324 means that subscription is paid to the 32d week (that is the issue of Aug. 11) of the year 1904; the change of these figures is the only receipt, unless one is sent by special request.

ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

"Hot Air" is the very apt title of a little pamphlet which has come into our hands, describing an apparatus which is alleged to be capable of pulling hot air with great velocity into a ..re under a steam boiler and thereby obtaining "a very much greater efficiency out of each pound of coal burned." A cut of a horizontal tubular boiler is shown in the pamphlet, with an illustration of the apparatus, and how it is supposed to work. Some coils of pipe are placed in the flue connection, where the gases leave the boiler, with an inlet for cold air and an outlet for the heated air leading from the coil into the lower rows of tubes of the boiler. Arrows show that the hot air passes through these tubes toward the rear connection where the highly-heated gases of combustion enter the tubes, then gets across or through these gases in a manner we are unable to understand, so that it gets below them, travels in contact with them but in a contrary direction, and passes over the bridge wall into the fire while the smoky gases from the fire are shown to be passing above them. How this remarkable course of the gases can occur is thus explained:

> Said air, while passing through the length of the tube, is heated to a high degree of temperature by the escaping gases. On reaching the end of the tube this air is drawn, by a vacuum existing in the fire chamber, through the lower line of boiler tubes, to the fire, where coal is saved, and where better combustion takes place.

In all ordinary boiler furnaces and settings a higher degree of vacuum exists at the flue than at the fire chamber, and this causes the hot gases to travel towards the flue. In this furnace, however, there appears to be two different vacuums, acting independently and in opposition to each other, yet without conflict. One of these vacuums causes the hot gases to travel from the fire chamber towards the back connection, while the other causes the hot air to travel from the back connection to the fire chamber.

A similar device was described more than four years ago, in our issue of Feb. 16, 1899, under the heading of "The Schlicht Process of Combustion," said to be the invention of Mr. Paul J. Schlicht. We believe Mr. Schlicht got many people to try his apparatus, but it seems to have disappeared from the market.

Our readers may draw their own conclusions as to the probable fate of this later device, and if our description of it is not sufficiently extended doubtless a copy of the pamphlet in question can be obtained by addressing the Coal Saving & Heating Co., of 500 Fifth Ave., New York City.

The need of greater care in wiring and equipping electric cars which are to operate on elevated or underground railways has again been illustrated with terrible emphasis by the disaster which occurred on Aug. 10 on the new underground railway in Paris. In commenting on the much similar accident which happened on the Liverpool overhead railway on Dec. 23, 1901, we called attention to this species of danger in electric railroading and particularly to the possibilities which it offered for horrifying loss of life when encountered in tunnel or on elevated structure. In our issue of Jan. 23, 1902, we published a communication made public by Mr. Geo. Westinghouse, in which that well-known expert in electrical work presented the possibility of these same dangers in even stronger terms than we had ventured to use. The possibility of such an accident as has just occurred in Paris has, therefore, not been unfamiliar to engineers, and we know that in the most recent electric railway work it has been recognized by engineers and an attempt at least has been made to guard against it. To what degree these attempts will be able to meet successfully the crucial trial when it comes no one can undertake to foretell definitely, but they are unquestionably a move in the right direction.

It is idle to assert that the Paris accident has no lesson to offer to the builders of underground electrical railways in America. Besides the fundamental lesson that a radical advance is necessary beyond prevailing practice in the electrical equipment of high-power cars, the Paris accident teaches the necessity of fireproof car construction, of means for fighting fire within the tunnel itself, of ample room for the escape of panic-stricken people through the tunnel and past standing trains, of the necessity of frequent and roomy exits to the street surface, of efficient ventilation and of various minor precautions which will occur to everyone. We shall not attempt to discuss here how far these requirements are met in the underground electric railways now being built in America, the important point to be insisted upon is that the dangers responsible for the disasters at Liverpool and Paris and for the multitude of fires on surface electric cars which are happening every year shall be recognized and guarded against in every possible way. In urging this point we are not arguing against electric traction. The substitution of electric propulsion for steam locomotives on all city railways is bound to be accomplished, but it is the duty of the electrical engineer to recognize that this change brings with it its own special dangers and to see to it that these dangers are reduced to the lowest possible limit. Evidently the first step to this end is the adoption of fireproof car construction for tunnel lines, and something has already been down toward bringing this about. Another and a still more important step is to introduce such improvements into the wiring and electrical equipment of cars as will reduce the danger o. fire, if they do not eradicate it.

The proposition to use cables made up of nickel-steel eye-bars for the Manhattan Bridge across the East River at New York City gives particular interest to the paper on the properties of nickel steel which is published elsewhere in this issue. Of all the various alloys of steel which have come into prominence in recent years, that of nickel and steel admittedly presents the greatest promise of general utility for engineering purposes, and not a few engineers have imagined that the no distant future would see carbon steel extensively replaced by it. As a matter of fact the amount of nickel steel which is used is surprisingly small considering the truly remarkable qualities of the metal. To put the condition plainly, nickel steel has gained merited favor for certain special purposes, but it has not been seriously adopted for the multitude of general purposes for which simple steel is employed, nor is there reason to expect that it will be so employed unless the circumstances controlling its production undergo a material change.

There are two good reasons why nickel steel must have a limited employment in engineering construction. The greater cost of the alloyed steel is one of these reasons and the other is that there is a physical limit to the production of nickel steel and this limit is far and away closer than may be realized at first thought. With nickel at the market price of 50 to 60 cts. per pound, a ton of 3% nickel steel will cost from $30 to $35 more than a ton of carbon steel. It is well known, however, that these market prices have not been paid for most of the nickel sold by private purchase, but assuming that it can be had for for 35 cts. per pound, we still have an added price of about $20 per ton, or 1 ct. per pound. This is a high premium to pay for the superiority of nickel steel, and it is not likely to be paid in any but exceptional cases.

If nickel steel and carbon steel were to be had at equal prices, however, its use would still be limited by the ability to produce it. The world's production of nickel in 1901 was 10,400 tons. Employed in the usual proportion of 3% as an alloy of steel, the nickel output of 1901 would make about 350,000 tons of nickel steel. This figure establishes the physical limit of nickel-steel production at the present time. For obvious reasons the commercial limit is much below these figures. The bulk of the 10,400 tons of nickel produced in 1901 came from the Canadian mines and those of New Caledonia, and the increase in nickel production for many years has been due wholly to the greater output from year to year of these well-known nickel-producing districts. For many years no new mines of nickel ore of any great importance have been discovered. Under no circumstances, therefore, which we have any reason to anticipate can nickel steel constitute more than a small percentage of the steel consumption of the world. This is a fact which it is important to keep in mind in any speculation upon the future development and possible uses of nickel steel in engineering works. Respecting the value of the new alloy for certain special purposes there is, however, no dispute, and it is entirely reasonable to expect that it will be used in increasing quantities for such purposes as time goes on and its merits are more generally recognized.

LESSONS IN SANITATION AFFORDED BY A RECENT TYPHOID EPIDEMIC AT MARSHALLTOWN, IA.

A shameful lack of proper municipal sanitation has been revealed by a recent special report of a committee of the Iowa State Board of Health. If the strange disregard of sanitary precautions described in the report named were confined to one small city the incident might be passed over in silence, but doubtless there are hundreds of other small and scores of larger places in no better sanitary condition than the committee found Marshalltown, Ia., at the time of its investigation.

An epidemic of typhoid fever occurred in the city named during March, April and May of the current year. At the request of the health and sanitation committee of the city council of Marshalltown, the State Board of Health investigated the outbreak through a committee consisting of Dr. Chas. H. Hoffman and Dr. Eli Grimes, Bacteriologists, of Des Moines; Prof. J. B. Weems, Chemist, of Ames; and Chas. Francis, Civil Engineer, of Davenport.

It appears from the report that up to June 15 there had been, as nearly as could be learned, 41.. cases of typhoid fever in the city, "of which 167 had occurred among school children between the ages of 14 and 18." The population of the city in 1900, it may be added, was 11,544. With the outbreak itself we need not be further concerned in this article, except as the statements bearing on

the sanitary neglect of the city bring out various points regarding the epidemic.

The first notable feature of the report, then, is a statement regarding the difficulty experienced by the committee in its search for the origin of the epidemic. The committee says:

The discovery of the origin of the epidemic in your city is a rather difficult matter, as no classified health and death returns from each ward of the city, also reports as to use of private wells or city water with respect to cesspools or private vaults, or modern closets with respect to milk consumed from private sources, or general sources, with the conditions surrounding such sources, were available to aid in discovering the source of the contamination.

A similar lack of official reports of cases of typhoid fever appears to have existed at Ithaca, N. Y., at the time of its recent typhoid epidemic. Possibly a place of 11,000 inhabitants, at the opening of the twentieth century, may be excused if it has no records showing the source and character of the water and milk supply of each house, but it certainly would be hard for it to justify its failure to require prompt reports by physicians of such dangerous communicable diseases as typhoid fever, and careful registration of the same by a proper municipal officer. There are at least a few places no larger than Marshalltown whose health officers are able, on a minute's notice, to tell the source, if not the character, of the water supply of each house, while before an epidemic of typhoid could get well under way the source and character of the milk supply, and much regarding all other possible common sources of infection, would also be known. The lack of knowledge at Marshalltown, as to the character of even the public water supply, to say nothing of private wells, and certain shocking conditions pertaining to a portion of the milk supply, are brought out by the report.

On the subject of the public water supply the committee says, in part:

The water supply of Marshalltown is derived from a water-bearing stratum of sand collected by 40 wells connected to a 24-in. pipe, by which the water is conveyed to the pumping station. The area under which this water-bearing strata lies is about forty acres, and it is about a half-mile northwest of the pumping station. The wells by which the water is collected are 4-in. pipes, driven 22 ft. into the sand substratum; in connection with the system of wells is what is called a filtering gallery, which consists of a perforated pipe about 3,000 ft. long, on the hard pan at the bottom of the water-bearing sand, say about 20 ft. below the surface of the ground. This pipe is connected directly with one of the wells in use at the pumping station. Analysis shows that the water is seriously contaminated and wholly unsafe.

This gallery must be disconnected from the system at once.

Analysis appended, chemical and bacteriologic, from the wells, shows that the water from the system of wells is wholly safe and wholesome for drinking purposes. The only possible source of contamination from these wells that is apparent is in connection with the system of back pressure, as it is called, by which the strainers, which terminate the pipes, are cleaned. The back pressure is furnished from a separate well, which is open and in which the level of the water is nearly to the surface of the ground, and is, therefore, liable to become dangerously contaminated. This well must be discontinued and the back pressure obtained from a well properly constructed; or else from the pumping station. At the pumping station the receiving wells are, as at present constructed, not free from danger of contamination; there being no pretense of keeping out the river water or surface drainage, not even being provided with air-tight cover, thus being subject to danger of contamination. The receiving wells should be replaced by bottle-tight wells constructed in the most solid and substantial manner.

Without attempting to pass judgment on the evidence that the public water supply did cause the epidemic, or a portion of it, it may be said that, judging from the report, the city apparently knew little regarding the actual or possible sources of contamination of its public water supply.

The quality of the water from many of the private wells in the city is declared to be bad, the bacteria ranging from 8,000 to 22,000 per cu. cm., and the chemical analyses showing evidences of serious contamination. Many wells were found "in close proximity of privy vaults."

Coming now to the milk supply the report indicates a most serious state of affairs, for although the "rules of the State Board of Health are quite explicit" in the prohibition of the sale of milk by dealers in whose houses typhoid or other communicable diseases exist, and in forbidding dairymen and dairy employees from entering houses where there are cases of such diseases, yet the report (condensed) states:

Persons having typhoid fever in their homes were permitted to sell milk while caring for those so afflicted. Inside of three weeks after the appearance of the disease in their homes, cases of typhoid fever occurred among their customers. In another instance persons having small-pox in their homes were permitted to sell milk without having undergone any period of quarantine.

Some cases of typhoid fever are directly traceable to infected milk. The premises of some of the dairymen are very unsanitary and unhygienic; also their wells are badly contaminated. The bacillus quite frequently finds its way into the milk from the wells or from the water used in rinsing the cans or diluting the milk.

Some of the dairymen supplying the city, on the other hand, have splendid facilities and their dairies are evidently in excellent condition. The milk samples purchased in the open market showed no impurities from a chemical point of view, although the bacterial contents in some of them were rather high.

We desire to direct your attention that your city should have an ordinance providing for the licensing and inspection of dairies and the premises of individuals who supply the city with milk in order that the proper control may be exercised and the health of the community be protected.

The recommendation in the last paragraph quoted is particularly good. Coupled with the licensing of dairies, however, or rather with the licensing of dealers in milk, might well be a provision that every dealer, once in three months, must file with the local board of health, or dairy inspector, a list of all dairies from which he buys milk, and of all customers to whom milk is regularly delivered by him. In many, if not most cities, there are a number of milk dealers who have no dairies, or who buy from other dairies a portion of the milk which they deliver. If all the dairies from which a city's milk supply is drawn are to be inspected by the health officials it is therefore necessary to have each licensed dealer file lists of the dairies from which his supply is taken. The lists of customers supplied by each licensee aids the health officer, when tracing the cause of an epidemic, in arriving at conclusions regarding possible common sources of infection. These customer-lists, however, are of far less importance than the dairy lists, for in the most efficient health board work a competent inspector takes up each reported case of typhoid fever, and ascertains, by a personal visit to the house in which the patient is confined, the normal water, milk, and other food supplies of the patient, together with any departures therefrom. The milk-dealer, or changes therein, if already on record, will be learned during such a visit.

One other deplorable sanitary condition may be noted. The committee declares (condensed):

In your beautiful high-school building, with its arrangement of rooms and halls, evincing great study and skill in its design, there has been given not even a passing thought to any system of ventilation and plumbing. The plumbing throughout the building, as well as some of the other buildings, is antiquated and not up to the standard of modern scientific requirements.

The water supply of the high-school building is contaminated by the foul air which arises naturally and without hindrance from closets in the basement of the rooms, in the attic, where the uncovered water tanks are. In fact, this foul air is led directly from the closets in the basement to the tank room by the flue containing a steam pipe, which leads into the tank room through a large hole in the flue, the hole being open all around the steam pipe, the hole furnishing considerable ingress for foul and bacteria-laden air. That the water tank absorbs some of the dangerous elements of the foul air is conclusively shown by chemical analysis, also by the bacteriological examination.

Perhaps too much stress has been laid, in the matter quoted, on some of the specific dangers from poor plumbing and ventilation, but neglect of elementary sanitary principles is unquestionably shown.

Finally, the summing up of the evidence as to the cause of the epidemic and the need for future precautions may be quoted, in substance, as follows:

It would be difficult at this time to state whether the city water supply could be considered responsible for the epidemic or not. It would be a presumptuous matter to state at present what the condition of the water was prior to March 15th. That the system was subject to contamination cannot be denied, nor can there be any question that the majority of cases can be traced to direct infection from persons already infected. Other probable sources of contamination already existed. The large number of children taken sick from the high school, together with the isolation of the bacillus out of the water tank of that institution, shows the origin from that source. From the data which we could obtain we find that at least 40 cases of typhoid fever existed prior to the appearance of the epidemic, or before March 12. From the carelessness which had been manifested in paying no attention to the details of cleanliness about the sick, in sterilization of all articles soiled about the sick, and the proper rendering innocuous of all urine and fecal discharges of the patients, it remains an open question whether these lax methods may not be held accountable for the spread. When it is borne in mind that the life of the bacillus causing enteric fever in city water is very short lived (five to seven days), whilst under favorable conditions of moisture and the free admixture of organic matter, it may exist in the soil for months; and also that the urine and feces of patients contain the germs in large amounts, it becomes evident that the immediate and proper disinfection of these excreta constitutes the main barrier against the further spread of the disease.

It would further be well for cities of your size to provide for a hospital to which individuals living in crowded districts and in poverty could be taken and cared for.

We would also recommend that your board, upon the advice of its health officer, adopt some uniform method of disinfection of all excreta in typhoid fever. A great number of so-called disinfectants such as lime, ammonia, etc., are entirely insufficient to insure proper disinfection.

Many, if not most, bacteriologists would doubtless question the isolation of the typhoid bacillus from the water tank of the high school building, but that does not affect the sanitary teaching of the report as a whole.

LETTERS TO THE EDITOR.

Strips of Macadam in Residence Streets.

Sir: I wonder if you intended that your suggestion of narrow macadam in residence streets, in your issue of Aug. 6, should be taken very seriously as expressing a reasonably strong opinion or only a passing thought put forth for the purpose of provoking discussion?

A certain village has a single macadam street with many intersecting improved streets. Observe the condition of the macadam roadway; it is covered with mud or is kept clean with great difficulty and expense.

I fear the same result would obtain on a narrow strip of macadam in the center of a residence street.

Except on streets used for speedways, the greater portion of the traffic is such as seeks the side of the road at short intervals and would, therefore, in muddy times certainly carry the mud onto the macadamized center, not to mention the unpleasantness and damage to vehicles of driving on the muddy sides.

Where the soil is very sandy or gravelly your suggestion would, perhaps, work well. But would it not be much better if the street be a wide one, to narrow up the roadway to a minimum comfortable width, pave the whole of it, and leave wide sidewalk areas to be improved with grass, shrubs, and flowers?

Another alternative is to make a double driveway, parking a strip along the center. This involves more difficulty in arranging for proper care of the footway, but is very effective where well done.

I think I should hesitate a long time before advising the paving of a portion of the width of a residence street.

I should much prefer to advise a cheaper improvement of the whole width.

It is really wonderful what good drainage and a little good gravel well handled will do. Wm. G. Raymond.

Troy, N. Y., Aug. 13.

(Replying to our correspondent's query we have to say that it was more than a passing thought that prompted the writing of the editorial suggesting the more general use of narrow macadam in residence streets, but the purpose of the editorial was to provoke discussion. To engineers acquainted with the extensive, and we might say the almost exclusive use, of narrow macadam and telford pavements in the towns of northeastern New Jersey, it seems remarkable that so many towns and cities elsewhere cling to the idea that streets must be macadamized the full width or not at all. The objection to narrow macadam, raised by our correspondent, is not a new one, but it is one that has doubtless caused many an engineer to hesitate in recommending the macadamizing of less than the full width of the roadway, and we shall welcome further discussion of the subject.

In such discussion it is desirable to have actual records given of the ill effects, if any, arising from narrow paving.

The earth of the shoulders at the sides of many of the paved streets in New Jersey is largely clay that ruts badly and clings to the wheels when water soaked. Nevertheless, due to the sharp crown that the macadam usually has the paved portion of the streets is remarkably clean as a rule, for occasional rains serve to wash off any slight amount of earth that is tracked onto the pavement.

That the amount of clay so tracked onto the pavement is small can be confidently asserted. When the soil is dry, vehicles more often leave the macadam than when the soil is water soaked, but

when it is dry of course little or none of it sticks to wheels or hoofs. But in any case, even where blocks occur with houses close together on both sides of the street, necessitating frequent passage of delivery wagons onto the earth part of the street, one looks in vain for any evidence of accumulated mud on the macadam. As to using a cheaper material than macadam for improving the full width of a street, what shall it be? Gravel, if properly laid, is certainly far preferable to no

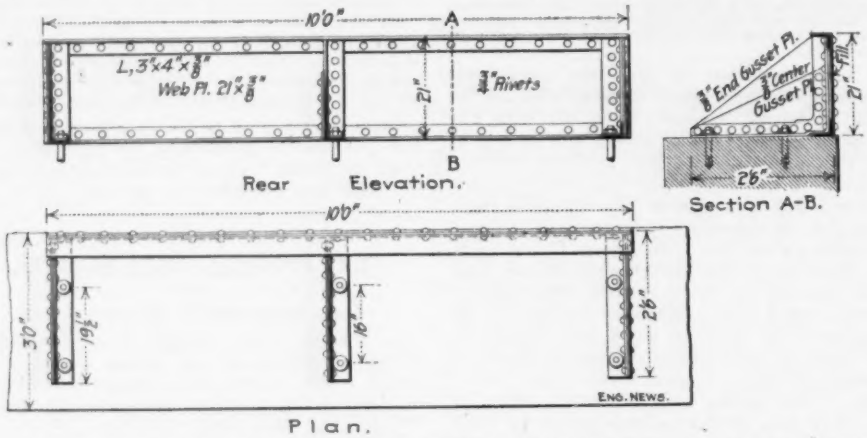


FIG. 1. RIVETED PARAPET FOR MASONRY BRIDGE ABUTMENTS; C., B. & Q. R. R. (1884).

pavement at all, and it has been used to advantage in covering the earth on both sides of a narrow macadam pavement; but in some localities good gravel is scarcer than broken stone, and in any event it is questionable whether a curb-to-curb gravel is anything like as good as a center strip of macadam. With the general proposition to narrow the paved portion of residence streets, and throw the space into grass, we are heartily in accord, but roadways are rare that can be made so narrow as not to affect a considerable saving by the use of macadam in the center, with dirt at the sides. Moreover, the traffic near the curb of many residence streets, is too light to keep macadam placed there from going to pieces, and it is hard to keep weedy grass and real weeds down in these little-used strips of macadam.

Finally, when it is a choice, as it is in many small communities, between laying two miles a year of 16-ft. macadam strip, and only a mile or so of macadam from curb to curb, can there be any doubt as to the proper course to pursue?—Ed.)

Mountain Tunnels and Switchback Lines.

Sir: In the interesting editorial article on large tunnel works, in your issue of Aug. 13, reference is made to the American practice of building a switchback line to serve until such time as the traffic will warrant the expenditure for a tunnel line, and it is implied that the European engineers might well have done this in the case of the Simplon. A consideration of the conditions will, I think, correct this impression. Before the Mont Cenis tunnel was built, the first of the great Alpine tunnels, an "open-air" high-level railway had been built to effect the crossing of the mountains at the Mont Cenis Pass, and I believe this was a switchback line. This railway was built about 1867 by an English engineer, Mr. Fell, and his grip-rail system of track and locomotives was employed to allow of operating very heavy grades. The Mont Cenis tunnel was opened in 1871, and the switchback railway was then abandoned, as has been the case with several such lines in this country. Thus the "temporary expedient" of a switchback railway was actually adopted for the first crossing of the Alps by railway.

The case of the Simplon, however, presented different conditions. When the Simplon railway or Simplon tunnel project arrived at a definite stage, there were already two railway routes crossing the Alps by tunnel—the Mont Cenis and the St. Gothard lines. The object of the third route—the Simplon—was largely to afford a quicker and better route for through traffic, and so to benefit certain districts tributary to this new route. But better and quicker facilities could hardly be afforded by a switchback line, with heavy grades and liability to trouble from snow, etc. It would have been out of the question to expect that mails and passengers sent by "the overland route" to make a saving of time between eastern Europe and Asia (as compared with the slower steamer journey east of Brindisi), would be sent over a switchback line when two substantially built lines having low-level tunnels were available. Under these conditions, therefore, it would seem that there was no use in considering the construction of any temporary railway across the Simplon, but that it was far better to save the money and time required for such a line and to concentrate all efforts upon the one grand scheme for a substantial and permanent line which would have advantages over the other and older lines.

Yours very truly,

Chicago, Aug. 15, 1903. Railway.

Metal Curb for Masonry Bridge Abutments.

Sir: I have read the article published in Engineering News of July 23 about an iron parapet or curbing for use on railway bridge abutments with a great deal of interest, because the same or a similar device has been in use upon the Chicago, Burlington & Quincy R. R. for somewhat more than twenty years. It was originally designed by the late R. J. McClure, at that time Chief Engineer. The accompanying drawings, Figs. 1 and 2, show the earlier and present forms of iron parapet, the latter being still in use and giving us entire satisfaction.

Yours truly, C. H. Cartlidge,
Bridge Engineer, C., B. & Q. R. R.

209 Adams St., Chicago, Ill., July 25, 1903.

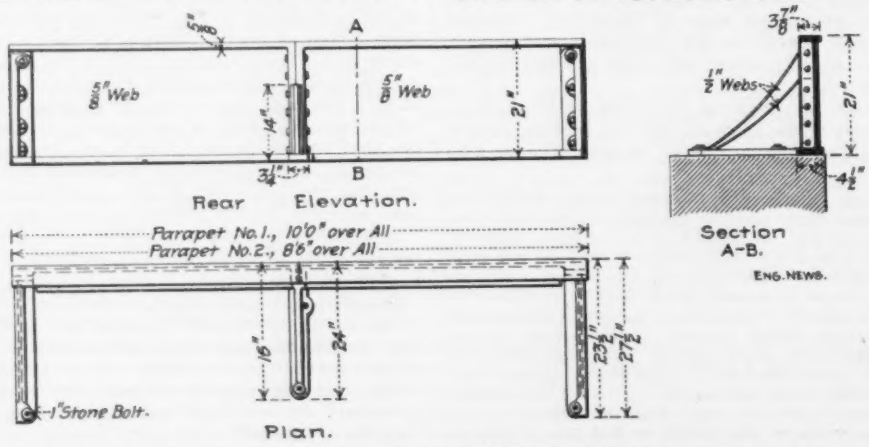


FIG. 2. CAST-IRON PARAPET FOR MASONRY BRIDGE ABUTMENTS; C., B. & Q. R. R. (1887).

(It will be seen that the riveted curb, Fig. 1, is practically identical with the German curb shown in our issue of July 23, and referred to in the above letter. The credit of prior use appears to belong to the Burlington, therefore. In a recent issue of the "Centralblatt der Bauverwaltung" is shown a style of curb used on the Magdeburg railways of Germany, which differs from either of those shown above. We reproduce the sketch as Fig. 3. The curb consists of a 12-in. channel anchored back by bent angle brackets riveted to the channel and hooked over the back of the masonry. The curb does not require to be bolted to the masonry, but is held in place by the pressure of the filling on the angle brackets.—Ed.)

Note and Query.

In the communication from Prof. W. K. Hatt regarding Rational Formulas for Concrete-Steel Beams, published in our issue of Aug. 13, the statement 20% of metal should have read 2% of metal.

LAYING A HIGH-PRESSURE GAS MAIN ACROSS THE MISSISSIPPI RIVER AT NEW ORLEANS.*

By Thomas D. Miller.†

The New Orleans Lighting Co., having decided to supply gas to the city of Algiers by means of a high-pressure main laid on the bottom of the Mississippi River, old and experienced river men were asked as to various points involved in the proposed work, and several engineers were consulted, but the majority of them regarded the plan as unfeasible for the following reasons: (1) The extreme depth of the river; (2) the constantly shifting bed; (3) the swift current in the main channel; (4) the wrecks lying in the bed of the river.

The laying of this main was the scheme of Mr. F. H. Shelton, and the work was done under his general direction. The following description of the work was given to us by Mr. W. D. Marshall, superintendent of the plant, and Mr. M. L. Goldman, his draftsman. Mr. Marshall was in charge of this work, under the direction of Mr. C. T. Sloan, whose experience has fitted him to take charge of a work so unprecedented in its character.

The head of Julia St., New Orleans, was selected as the point for laying the pipe, because it was conveniently located for the high-pressure main leading from the gas

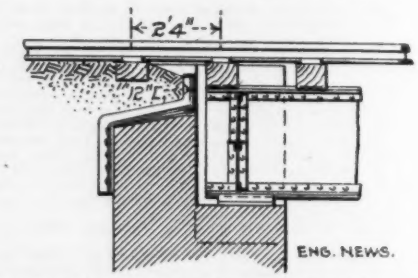


Fig. 3. Abutment Curb Used on Magdeburg State Railways.

works. There was no special dock constructed at this point. The levee was low here, and the point in Algiers immediately opposite was a desirable one for entering. The accompanying cut shows the profile of the river and of the pipe line. Having located by soundings the exact point at which the pipe was to enter the water, the power to be used in pulling the pipe across the river was considered. The consideration of locomotives was abandoned owing to local conditions. A large derrick boat, with modern machinery, was engaged. This boat had a capacity of lifting, on a straight pull, 75 tons. All of the pipe and protecting sleeves were taken across the river to a point near where the pipe was to enter the water. A ditch was dug at the point selected at right angles to the water line, and as this side of the river bed is very steep, no trouble was anticipated from the friction on the bank after the pipe was once started into the water. At 50 ft. from the water's edge the sounding showed a depth of 60 ft., while 250 ft. out there was a depth of 120 ft.

A length of pipe about 250 ft. long was then screwed together, each joint being screwed up as tightly as possible, four pairs of extra long and heavy pipe tongs of lathe pattern being used. It was considered extremely important that the threads should be entirely taken up, and that no threads should be crossed; because in hauling on the cable to draw the pipe line across the cable, by untwisting as the strain came, tended to loosen the joints by starting the threads. Each joint was coated on the threads with asphaltum iron paint, for the double purpose of preservation and preventing leaks. Each coupling was inclosed in a split sleeve of cast steel, weighing about 300 lbs., about 3 ft. long, and held together by eight ⅝ x 4-in. bolts, with washers at each end; the bolts being split at the end to rivet them on. The first three sleeves were screwed as tightly as possible, and the remainder moderately tight, in order to allow some little play. The shore end of the pipe was kept closed with a short length

*Abstract of a paper read before the Western Gas Association.

†New Orleans, La.

of pipe with a plug in it, so that in case the pipe got into the river it would not fill with water.

The water end of the pipe was a short length of pipe with a solid coned end, about 1 ft. long, having at its end an eye to which was shackled the hauling end of the cable. The cone was intended to cut through obstructions which would otherwise stop it. The pipe itself was the best 6-in. Allison, upset end, steel pipe. The threads were specials, and were made plus, being on the collars, so that the threading did not weaken the pipe at all. The threads had an extra taper and the ends of the pipe were faced, and were intended to set flush with the end of the next joint. A stout post was set up near the line of the pipe, and a line was taken around the pipe about 20 ft. from the end, and a turn taken around the post, so as to snub the pipe as it went into the water.

The cable used in hauling the pipe, made by Roebling's Sons Co., was the best steel wire cable on the market, with a breaking strength of 120 tons. Part of the cable was 1 in. diameter for the lighter pulls, and the remainder was 1¼ ins. for the heavier pulls. The cables were joined by coned ends and shackles, and reeled up on the side of the river opposite to where the pipe was ready and a brake arranged on the reel. The end of the cable, with plenty of slack for connecting with the pipe, was put on a barge and made fast by chain grips. The barge was then taken in tow by a tug, and the cable guided across the river in as straight a line as possible, a range being taken which took into account the current, etc. When near the shore a second tug came alongside the barge and pushed it to the shore. The end of the cable was immediately shackled to the end of the pipe line, and the cable cast loose from the barge and thrown overboard. All was now ready for pulling. The first attempt to take the cable across failed because of some carelessness in the winding of the cable on the reel. The second time the cable was wound boards were put in lengthwise to the reel so as to give a snug, neat coil, and also to keep the shackles from fouling. The brake was discarded and boards used as a hold-back on the edge of the drum.

When the far end was made fast to the pipe line and everything was in readiness, a fall was hitched to the cable with chain grips and hauled taut, acting as a stopper, and the cable was unreeled to the next shackle and unshackled and led to the drum of the hoisting engine of the floating derrick, on whose deck the work was being done. This derrick was securely tied to the shore and the reel strongly secured to the derrick. A trench about 8 ft. long was dug about 250 ft. from the shore line and parallel with the water's edge, and two large pieces of timber, 8 × 16 ins., put into it. A second ditch was dug towards the river and a short cable passed with a round turn around the timber, and the ends clamped with special cable grips. A second short cable was hooked on to the first and taken along the ditch to the water's edge, and a large snatch block shackled to it.

When all was ready the cable was passed through the snatch block as a fair lead to the drum of the windlass and the signal made, "Ready to haul," which was answered from the other side, and the haul was then made. When the end of the pipe came near the water's edge, the signal was made "Stop heaving." The plug end was then removed, the next joints of pipe screwed on in succession, and the plug joint replaced for another haul.

The first hauls were easy, and unless obstructions were met with, offered no difficulty. Some obstructions near the shore on the pipe side gave some trouble, necessitating the use of a luff on the cable. This was hitched onto the cable with a chain-grip and taken to the bitts and a rope taken around the gypsy on the windlass and hauled in. The large sleeves seemed to be the thing which caused the trouble, and the first two or three had apparently cut their way through timber obstructions, the others having followed readily.

The pulls became heavier and heavier as the line entered the water. The cable was then stoppered, and the snatch block taken from the end of the line on the deadman. The line was shortened in until about 200 ft. from the bank of the river, and an extra heavy 22-in. two-sheave block hooked on. A second block with three sheaves (only two sheaves were used in hauling, no heavier pulls being required) was gripped on the cable. A cable was then rove on these large blocks, and the hauling part leading from the fixed block was taken down to the windlass through the snatch block, the position of which had been reversed. The cable was then hauled in. When the luff came two blocks, the large block was hauled back for the new pull by the gypsy.

When the line of pipe was just outside the hull of the derrick, the cable was stoppered, then slacked from the shore side and taken around under the barge, which was done on account of the construction of the wharf and the levee at this point. When all was ready again and the cable gripped for hauling, the stopper was eased off and the line of pipe hauled out of the river right through the mud of the bank, and about 15 ft. from the water's edge, apparently in excellent condition. About 15 ft. of the line was hauled out of the New Orleans side of the river, and it slipped back when the tension was removed from the cable. The work was considered successfully completed at this point.

The cable was taken across and attached to the pipe line at 5 p. m., Saturday, June 28, 1902. The first haul was made about 6 p. m., and the end of the line came out on the New Orleans side at 10:15 a. m., Monday, June 30, making the total working time of connecting up and pulling the pipe into the water about 32 hours. No work was done Saturday night after the first pull was made, but was resumed Sunday morning at daylight and continued straight through till the pipe was brought out of the water Monday forenoon. About 2,100 ft. of cable reached across the river, and about the same amount of pipe was used.

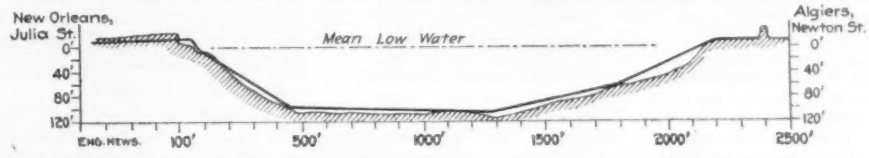
One of the conditions of the permit of the Port Commissioners was that the pipes on the New Orleans side should be placed 25 ft. below low water at the dock line, and 30 ft. on the keel, as this was the site of a proposed dock for ocean steamers. When the work was finally completed the pipe was 10 ft. below low water at the dock line, and about 15 ft. on the keel, the Board having consented to let it go at that with the specific agreement that the pipe would be lowered when the company was notified to do so. The low pressure line was partially down in Algiers, the governor station was completed and gas was turned on in the Algiers district early in November, 1902, and consumers were being taken on rapidly.

About two weeks after the gas was on the Engineers of the Board of Port Commissioners, Messrs. Coleman, Malochee and Villere, notified the company that the contract was let for the construction of the new dock, and that the lowering of the pipe should be proceeded with at once.

A large sand dredge was secured to pump the earth from beneath the pipe and thus permit the pipe to settle. In order to keep gas on all the time, and yet have a flexible connection, a section of pipe above the water was removed, and the pipe extended up to the dock level, and connection was made with 16 ft. of heavy 2-in. boiler hose. This was accomplished in two hours. The dredge was put to work in-shore and gradually worked out toward the channel, the work being directed on reports of a diver. This work was continued for three weeks, when we had the pipe all clear for 160 ft., but it had only settled about 4 ft. The pipe was free and could be swung by hand back and forward, but it would not go down any further. The river had been rising quite rapidly, and the work had to be abandoned for the time until low water. The 2-in. hose has been doing service all the time, and for more than two months past has been entirely submerged in the flood.

When the pipe was being pulled across the river, and the end was about 160 ft. from the New Orleans side, it looked for a while as if it would have to remain there, for the full power of the engine with three-fold block and tackle was stalled. The cable smoked alarmingly and showed signs of sparks on the winding drum. A luff was used on the cable and the obstruction was pulled through. When the end of the pipe was brought to shore, pieces of timber were found wedged in between the bolts, and the sleeve and some of the short ends of the bolts were bent over as though they had been struck several blows with a sledge. When the dredge boat weighed her stern anchor, which was buried near this point, an old hog chain was pulled up, evidently from an old wreck. I think, therefore, that the conclusion is perfectly warranted that the pipe is resting on an old wreck somewhere in that locality.

The service in Algiers is now entirely satisfactory. We have in use a combination regulator and governor. Wet meters cannot be used because the gas is so dry, after being compressed, that it literally drinks the water from a wet meter in a few days. We have had no trouble from water in the river main since pressure was put on.



PROFILE OF HIGH PRESSURE GAS MAIN ACROSS THE MISSISSIPPI RIVER AT NEW ORLEANS, LA.

DISCUSSION.

Mr. Shelton.—Two or three points might be added to the paper to make the record complete. The cost of work is always a matter of interest, and this pipe, in round numbers, cost $10,000 to put under the river. It is 2,000 ft. or over in length, and it cost somewhere around $5 a foot, laid. The pipe was put across the river to avoid building separate works in Algiers, which has a population of 15,000 or 20,000. A suitable plant (outside of distributing pipes and meter service) would cost about $25,000 or $30,000 for the present and some future years. This 6-in. wrought iron pipe to conduct gas at high pressure was with the idea that at high pressure it would be able to furnish as much as 1,000,000 cu. ft. of gas across the river. A 6-in. main at high pressure is by no means necessary to conduct the gas which will be used there for some time; but for stability, something tangible to handle, it was thought better to use a 6-in. pipe than to come down to a 5, 4 or 3-inch. I want to call special attention to the steady pressure condition that we find. The pumping plant at the works accumulates and maintains 15, 20 or 30 lbs. during the 24 hours, according to the conditions, on the high pressure pipe system. Sometimes the pressure may be 15 lbs., or it may be 30 (it more or less follows that range of irregular pressure through the high pressure mains), but no matter what the pressure may be or the fluctuation of intensity on the high side, the governor does practically and substantially perfect work, and the pressure stands at 30-tenths on the far side of the river night and day. A question of particular interest in going under such depth of water was that, with a low pressure pipe, it would be extremely difficult to take care of condensation, but high pressure would operate with less difficulty in deep water, because the tendency of high pressure gas, in the first place, is not to drop any liquor (that having been squeezed out at the works), due to the compression and to the fact that in any release of gas at high pressure the tendency is to absorb and pick up—the reverse of the effect of compression. We felt that the high pressure pipe, being some distance from the works, would operate, as a matter of fact, entirely dry, as far as any condensation from the gas is concerned, and in the several months in which the pipe has now been working I think such has been the result. Not a drop of liquor or moisture has been observed in the pipe, and the high pressure seems to eliminate the question of drip in the pipe under the river.

Mr. Goodnow.—All people who attempt high pressure, and especially in our western country and around Chicago, feel a great deal of interest in this matter of submerged high pressure pipe, from the very fact that at New Orleans it must be about as difficult a thing as could be brought into use by any company. Therefore, if this is successful we would feel perfectly safe in attempting such installations under smaller streams. I know several small streams that it will be necessary to cross in our district, but they will be mere brooks compared to the Mississippi River, so I think we can all feel at ease in the matter; that we can accomplish this without any difficulty whatever. I have not heard as to whether there was any question of electrolytic action on the pipe at New Orleans. I should think that the ground near the river would form an excellent circuit, if the trolley currents or the wires of the trolley lines were in such position as to come in contact with the pipe line. Has any method been adopted to cut this out? We found in our work corrosion of pipe by the current from the trolley lines, and we spent a great deal of effort, some money, and a good deal of worry in trying to find out just how to prevent this trouble. I think it is a question that will be the more serious because of the conductivity of a high pressure pipe, unless some means of insulation can be used to cut up and prevent the accumulation of the trolley current in returning to the power station. The method that seems to be most effectual is by cutting up the current by such insulating at different points as is found desirable from the volume and strength of the current running on the pipe. There are two methods by which this can be accomplished. The trolley people will tell you to bond your pipe to the rail somewhere near the power station, which will make the connection between the wire or the return into the station, and thus prevent action. This is very true at that point, but at other points a sleeve, or valve or joint will be affected by this action all along, and instead of localizing the action at or near the power station or sub-station, it will undoubtedly extend the flow, maybe throughout the whole line. We have reached the conclusion that we would rather localize the points of danger than to bond to the rails the return in that way. We have been at some trouble, and consulted several electrical experts in Chicago and Boston, and have worked under their advice. In doing this we adopted the second method instead of bonding to the rails at any point, and that is why I would like to inquire of Mr. Miller if he adopted any arrangement of that kind for the river line or for his entire high pressure system. The question of dry gas within short distance from compressors is confirmed, I think, by all people who have operated high pressure lines. I have tried a drip located about 500 ft. from the compressors. We never found any water to mention beyond this point. Before we put this in it traveled a little farther and we were unable to get it out, but about November or October we adopted the drip, and were then able to eliminate it and found nothing beyond this point. We were not troubled with any water or frost in service pipes, although we had 200 lamp posts on this line. The question of the cost of this line compared with the cost of a low pressure line for conveying gas across the Mississippi would be a small fraction, provided you wished to convey a million feet

across the river. It would undoubtedly take a 16-in. pipe, and several times the cost. As to the question of the amount this will convey, I think Mr. Shelton's estimate of one million feet is very low. I know of a plant near Chicago with a 6-in. line 6 miles long conveying 1,200,000 ft. in 24 hours with an initial pressure of 30 lbs., and losing 8 pounds pressure in that distance.

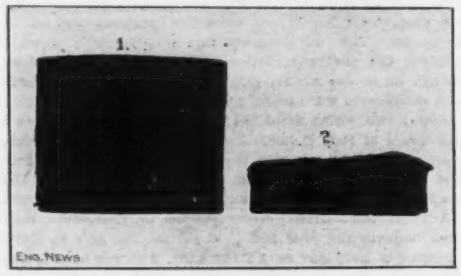
Mr. Rice.—I am greatly interested in this work because it accomplishes on a magnificent scale what I had attempted on a very small scale at Norfolk, Va. Across the river from Norfolk is a small town of about 5,000 people. We decided to attempt to supply it by laying a high pressure line under the river. On account of certain local conditions we finally settled on lead pipe, if the same could be accomplished. We laid a lead pipe between 600 and 700 ft. long, with a capacity which figures out about 8,600 ft. per hour, and it does better than that. That pipe has been in use a year and is giving perfect satisfaction. The pipe was pulled across the river in half an hour. It was put together on a large barge in about 12 hours' time by one plumber. The joints are stronger than the pipe itself. The pipe was simply laid around on the barge so as to have no kinks. The barge was pulled across the river. As I said, it was laid in about half an hour, coupled up at both ends and completed. At present we are putting about 2,500 ft. an hour through it. The pressure is scarcely noticeable; I should say 2½ lbs. It goes into a small holder on the other side of the river, which gives us a reserve in case of accident; but we have not had any accident. The pipe cost us 33.8 cts. a foot, and the cost of laying it was purely nominal. The pressure of the pipe is given by the manufacturer as 600 lbs., and as we have a working pressure of 3 lbs., we have a pretty good margin of safety. On the question of drip, we have not found any difficulty yet. The gas is perfectly dry and never accumulates any moisture. It seems to easily solve the question of supplying a very small town across a stream of water. I think the river is 34 ft. at its deepest point. The current is very swift, probably running there 7 or 8 miles an hour.

Mr. Miller.—When the New Orleans pipe was first laid, at the point on the profile, between 2,100 and 2,200 ft., is the mattress work. When the pipe was finally let into the ground and settled there was a bend in it of about 35°. Right there was a joint and the strain on that joint was too great for it. It broke the cast steel sleeve and pulled the coupling in two. The leak had been going on up to the time the pressure was put on. When pressure was put on it showed gas coming out, but it did not show until we had blown the water out of the pipe. Probably 40 or 50 ft. of pipe was filled with water. We put an air compressor on the New Orleans side and ran up the pressure to about 60 lbs., then opened the valve on the Algiers side and let her go. Considerable alluvium went out with the water. Since that time we have had no water at all. To repair, the pipe was cut in-shore, a derrick raised it out of the water, the broken coupling was taken off and a new one put on. The others were found perfectly intact. The pipe was then heated in-shore from this sleeve until it bent enough to give just the angle we wanted, and then lowered it back into the water. We have had no trouble since. We did provide a large tank on the Algiers side, so that in the case of any accumulation of condensation or water in the pipe that would be sufficient to resist the flow of gas, the pressure could be run up and the water blown out into the tank. Then it could be drawn from the tank by simply opening the drain pipe and letting the pressure force it out. There is a tank of similar character on the New Orleans side. The pipe enters the tank at one end and leads out at the other, so that any condensation coming in there will drop down in it. There has been little got out of this tank.

Regarding electrolysis, I have not had any evidence of it on any of the pipes in New Orleans. I have never made an electrical examination, and I doubt very much if we have very much on our pipes. The ground is so constantly saturated with moisture, I believe, from the character of the soil and the amount of moisture that it carries, that it is a pretty good conductor itself. Besides, the power stations of the street car lines are pretty well distributed over the city, so there is no great concentration of current coming to any one section of the town. As far as electrolysis in the river goes, I cannot see how there could be any, as there are no electrical lines connecting the two cities. I think the telephone company has a cable across the river, and besides that the pipe line is the only connection between the two towns; no bridges or anything of that sort of course. I cannot say, and nobody else can say, just how much that pipe swings down stream. It was pulled across at a fearful tension, but of course there was something of a tendency to swing from a vertical plane at the time because of the current. There are places which we know are 5 to 6 ft. above the ground. The tension on that pipe would be practically nothing. There is a certain bending moment in some portions of it in the bottom of the river. I think the tendency would be to gradually fill up under the body of that pipe, and finally probably the pipe will be entirely covered. On our high pressure lines at different points we have put in, in a district where there is a large quantity of gas going, a drip pot or drip tanks. We thought we were going to get a good deal of business there, but we did not. Very little condensation will accumulate. In the combination governor and regulator spoken of, the regulator brings the pressure from 30 or 40 lbs., or whatever the pressure is, to about 8 or 10 ounces. Then the governor brings it from that down to 28-10 to 30-10 on the other side. All of our stations are provided with blow-off tanks so that when the gas pressure gets high, or beyond a safe limit, the gas will blow off instead of bursting the leather diaphragms.

UNUSUAL WEAR IN CEDAR PAVING BLOCKS; DULUTH, MINN.

Some interesting views of cedar paving blocks, laid in 1888, have been sent to this journal by Mr. Edward G. Coe, Principal Assistant City Engineer of Duluth, Minn. The blocks were 6 ins. long, and were laid on a mortar-dressed concrete bed,



Comparative Wear in Cedar Paving Blocks at Duluth, Minn.

without a sand cushion. Tar and gravel was used as a filler.

Two of the views received are reproduced herewith. Block 1 appears to be practically unworn. Block 2 is scarcely 2 ins. thick, or long, but Mr. Coe say it "is still fairly sound." A third view, not reproduced, shows a block worn unevenly, its thinner part being 2¼ ins. deep. The block shows a sound grain, where split through the center.

RAILWAYS IN INDIA.

According to a report made by Mr. Brereton, Secretary of the Public Works Department of India, there were 566 miles of new line completed during the year 1902, while 630 miles more were completed by April 30, 1903, at which time the railway system aggregated 26,561 miles. Of this total, 14,346 miles were of the Indian standard gage of 5 ft. 6 ins.; 11,247 miles were of meter gage, and 968 miles were of narrow gages (nearly all 25 or 30 ins.). These figures include steam tramways outside of city limits. During the year beginning Jan. 1, 1902, the government authorized the construction of 1,107 miles, making a total of 2,895 miles authorized but not built at the end of the year. Up to April 30, 1903, other lines aggregating 170 miles had been authorized, and negotiations were then in progress for new lines aggregating 1,105 miles. Surveys have also been made for a number of railway lines, mostly branches and extensions.

The following table shows the growth of the railways and their traffic during the past 20 years:

	1882.	1892.	1902.
Miles of line open	10,149	17,815	25,893
Passengers carried (1,000s)	58,876	127,388	196,648
Freight carried (1,000s)	14,833	26,335	45,537

For the 20 years, there was an increase of 155% in mileage, 230% in number of passengers, and 121% in passenger earnings, while the average rate per mile decreased 19%. In freight traffic, the tonnage increased 207%, and the freight earnings, 109%, while the rate per ton per mile decreased 28%. There are four classes of passenger accommodation (rather unsystematically styled as first, second, intermediate and third). The lowest or "fourth" class is used more than all the others put together, and as it is used exclusively by natives it shows how much they travel, encouraged by the remarkably low rates. Of the tickets sold in 1902, 563,000 were for 1st class, 2,530,000 for 2d class, 6,813,000 for 3d class, and 171,716,000 for 4th class, while 15,016 were season and vendors' tickets. The rates per mile were 2.14 cts. for 1st class, 0.87 ct. for2d, 0.52 for 3d and 0.4 ct. for the 4th or lowest class. The average rate for all passengers in 1902 was 0.42 ct.; while the rate per ton per mile was 0.95 ct.

The train-mileage was 92,527,000; car mileage, 2,007,438,000; and ton-miles, 27,722,768,000. All these represent an increase over 1901, but the report states that the increase of 9.58% in passenger train mileage indicates the running of unnecessary trains, since the average number of passengers per train has decreased in several cases. The results of operation were as follows:

Gross earnings per train-mile	$1.18
Operating expenses per train-mile	0.58
Net earnings per train-mile	0.60
Operating expenses per mile of line	2,066
Net earnings per mile of line	2,170
Proportion of op. exp. to gross earnings	49.24%
Proportion of net earnings to capital	4.92%

The proportions of operating expenses to gross earnings in the several departments were as follows: Engineering department, 11.49%; locomotive department, 17.06%; car department, .20%; traffic department, 8.07%; general, 4.83%.

A report on the working of Indian railways has been made by Mr. T. Robertson, who was appointed by the Secretary of State for India (of the British Government) to investigate the difficulties which exist in the management of these railways, financially and otherwise. This report has been issued and is now under consideration by the government of India. In February, 1902, a conference of railway delegates was held at Calcutta, and it was decided to establish a permanent association, independent of the government, under the name of the Chamber of Indian Railways. The rules for the management and organization of this body are being considered by the boards of directors of the several railways. A technical report on the standardization of locomotives has been made by Mr. C. W. Hodson, Director of Railway Construction, who was recently instructed (while in England) to consult with English railway authorities in regard to relaxing the present standard dimensions or cross-sectional outlines for fixed works (platforms, etc.) and locomotives; in other words, the regulations affecting the clearance at stations, tunnels, bridges, etc. He also reported on the regulations regarding the strength of bridges, axle loads and weight of rolling stock.

During 1902, there were 205 engines, 684 passenger cars and 5,023 freight cars added to the equipment. There are 2,005 engines and 10,064 cars now fitted with automatic brakes, while 3,109 engines and 107,947 cars are not yet fitted; of the passenger cars, 8,080 are equipped with the Pintsch gas light, and 7,924 are not yet equipped. In railway accidents there were 1,231 persons killed and 1,141 injured, but trespassers and suicides account for 650 of the killed, while 29 were killed at grade crossings. There were 225 passengers and 306 employees killed.

The employees number 392,517, of whom only 5,875 are Europeans, while 378,373 are natives, and the remainder are Eurasians, or half-breeds. Of the Europeans and Eurasians, 12,022 are enrolled in the volunteer military service, for the instruction of which the army furnishes 121 sergeant-instructors. There is a provident fund for employees, and on the larger railways, schools are provided and maintained at all centers where the number of children is large enough to justify the employment of the teaching staff. The number attending school at the end of 1902 included 5,397 children and 3,983 apprentices and workmen.

There are 85 railway bridges which are over 1,000 ft. in length, but several of these are composed of a series of comparatively short spans. The largest bridge is that over the Sone at Dehri (East Indian Ry.), 10,052 ft., but composed of 93 spans of 100 ft. This was built in 1900. The largest spans are the 790-ft. span of the Lansdowne bridge over the Indus River at Sukkur (Northwestern State Ry.) and the two spans of 523.67 ft. of the Jubilee Bridge over the Hooghly River at Hooghly (East Indian Ry.). Many of the older bridges are being shortened by replacing shore spans and approaches with embankments. Thus the Alexander Bridge of the Northwestern St te Ry., crossing the Chenab River, was built in 1876 with 64 spans of 133½ ft. In 1891, changes were made and there are now only 28 of these spans.

There are 59 tunnels of 500 ft. (or more) in length. The longest is the Khojak tunnel on the Chaman extension (headed for Kandahar) of the Northwestern State Ry. This is 12,870 ft. long, carrying two tracks of 5 ft. 6 ins. gage. It was driven through water bearing shales and layers of soft mud, and two years were consumed in driving the heading.

ELECTRIC CONDUIT CONSTRUCTION AT CINCINNATI, O.

A special class of construction work which has developed very rapidly within the past few years is the construction of underground conduits for electric light, telephone, telegraph and other cables in the streets of large cities. As this work comes subsequently to the construction of sewers, water and gas mains, and other underground work, it involves many special problems and difficulties in avoiding these existing obstructions to the direct line of the conduit. The engineers and contractors for work of this kind, therefore, need to possess considerable judgment as well as skill in laying out and carrying on the work.

At Cincinnati, O., there was built last year a very extensive underground conduit system for the Cincinnati Gas & Electric Light Co. This system was for the purpose of supplying current to the street arc lamps in that district of the city where overhead cables and wires are prohibited. This district extends from Third St. to Liberty St., and from Eggleston Ave. to Freeman St., and has an area of 1.4 sq. miles. The general plan of the system was prepared by the engineers of the company, and all work was done according to lines and levels given by them. When the work was commenced Mr. Duman was the engineer; but Mr. C. N. Danenhower is now Chief Engineer of the Cincinnati Gas & Electric Co., and the greater portion of the work was done under his supervision. The contract was let to Mr. G. M. Gest, of Cincinnati and New York, and it was one of the largest single contracts ever yet let for an underground conduit system. Mr. W. R. Harris was engineer in charge for Mr. Gest.

In the district above mentioned, having an area of 1.4 sq. miles, 38.94 miles of trench were excavated, the depth ranging from 26½ ins. to 14 ft., and the width from 13 ins. to 9 ft. In the trenches were laid 1,056,891 ft. (200 miles) of conduit, in runs varying from one to 150 ducts. There were also built 888 manholes and service boxes. The smallest service box was 20 × 20 × 13 ins., and the largest manhole was 9.25 × 21.3 ft., and 10.1 ft. deep. The conduit used was of vitrified clay, both single and multiple duct, manufactured by the American Vitrified Conduit Co., of New York, and the H. B. Camp Co., of Akron, O.

For a single duct or two-duct run, trenches were excavated to a depth of 26½ ins., except where a greater depth was required to pass under obstructions. The minimum space between the top of the concrete covering the ducts and the street surface was specified as 15 ins., though this was often exceeded in avoiding other underground systems. The ducts in all runs were so arranged as to obtain as nearly as possible a square cross-section in the completed conduit. The ducts were laid in Portland cement mortar on a concrete foundation 4 ins. thick, and were covered with concrete to a thickness of 3 ins. No concrete, however, was placed on the sides of the tile conduits, except where wet soil was encountered or other unusual conditions prevailed. Joints of multiple duct tile were wrapped with a strip of asphalted burlap 6 ins. wide before the cement mortar was applied. A mandrel with a leather washer at the end was drawn through every duct as laid to clean out the tile and to preserve the alinement of the conduit.

The largest run constructed contained 150 ducts, and was composed of 25 six-duct multiple conduit 10 ducts high by 15 ducts wide, as indicated in Fig. 1. In the illustration, however, only four tiers of six-duct conduit can be seen, as the top tier is hidden by a trench brace. The 150-duct run extends from the underground receiving room of the power plant westward on Charles St. to Central Ave. On Central Ave., south to North Court St., a run of 137 ducts was constructed; thence to South Court St. a run of 113 ducts. The 137-duct and 113-duct runs were composed of both single-duct and multiple-duct conduit. For a 90-duct run on Court St. a trench 14 ft. deep and 6 ft. wide was rendered necessary. A 23-duct run, composed of five four-duct multiples and three single ducts is illustrated in Fig. 2. The gas main to the right of the ducts was moved a distance of 12 ins. for a length of 100 ft. so as to clear the line of conduit and also leave room for a working space around the gas main. A number of mains were shifted in this way at various places, and in one section the pipe was moved a distance of 4 ft. so as to clear one of the large runs. In one asphalt street the trench for a four-duct run was 4 ft. deep and 13 ins. wide. The depth originally intended was 31 ins., but owing to numerous service pipes the above depth was rendered necessary. Fig. 3 is a view of a trench 13 ins. wide and 26½ ins. deep, containing a single duct run. All ducts were wired.

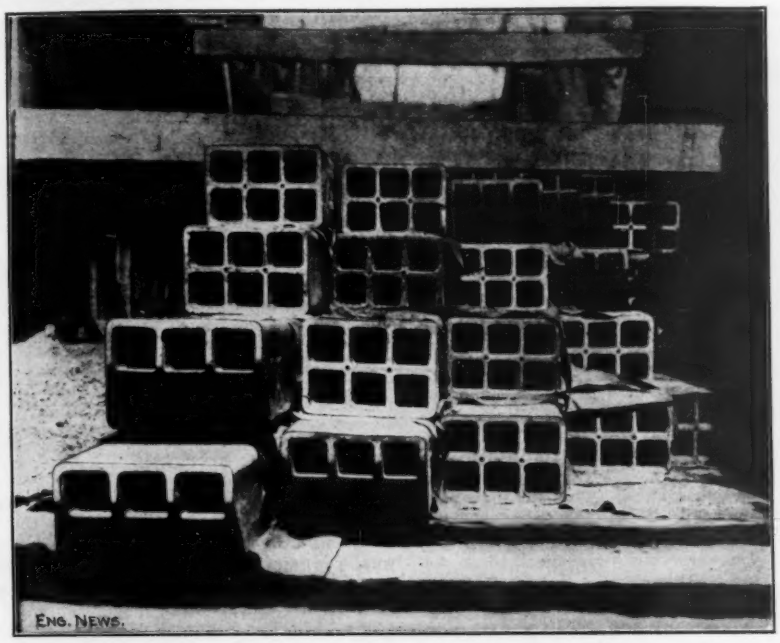


FIG. 1. ELECTRIC CONDUIT WITH 150 DUCTS: CINCINNATI GAS & ELECTRIC LIGHT CO., CINCINNATI, O.
G. M. Gest, Contractor, Cincinnati, O.
(The top tier of six-duct conduit is hidden by a trench brace.)

FIG. 2. ELECTRIC CONDUIT WITH 23 DUCTS.

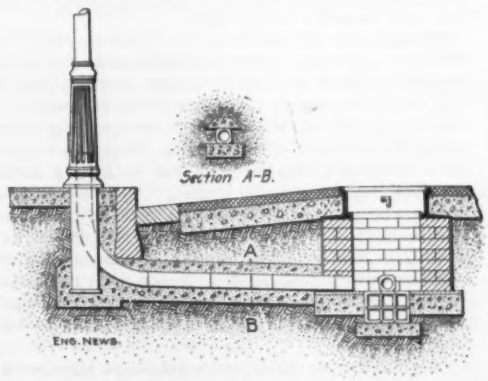


Fig. 3. Lateral Connection from Conduit to Lamp Post.

The following table shows the amount of conduit laid, with the length of trench and length of ducts for the different sizes of runs:

Schedule of Main Conduits.

No. ducts.	Trench, ft.	Duct. ft.
1	88,130.05	88,130.05
2	19,921.30	39,842.60
3	479.55	1,438.65
4	32,964.30	131,857.20
5	15.00	75.00
6	3,981.70	23,890.20
7	4,868.70	34,080.90
8	3,209.30	25,674.40
9	2,279.55	20,515.95
10	2,584.35	25,843.50
11	223.00	2,453.00
12	4,446.10	53,353.20
13	8,064.30	104,835.90
14	460.50	6,447.00
15	2,797.15	41,957.25
16	1,187.60	19,001.60
17	899.50	15,291.50
18	1,134.25	20,416.50
19	919.30	13,666.70
20	1,448.00	28,960.00
21	853.85	17,930.85
22	571.00	12,562.00
23	838.75	19,291.25
24	458.70	11,008.80
29	785.85	22,790.52
35	242.90	8,501.50
36	366.40	13,190.40
41	451.10	18,495.10
53	15.75	834.75
54	463.00	25,002.00
64	423.50	27,104.00
70	471.00	32,970.00
90	424.25	38,182.50
113	113.70	12,848.10
137	336.30	46,073.10
150	223.90	33,585.00
Total for main run.	186,853.45	1,038,100.97
Service conns,1 duct	18,790.60	18,790.60
	205,644.05	1,056,891.57

Service connections were run to 922 lamp pedestals. The construction of these connections is the same as for a one-duct run as far as the curb, but here the duct run terminates in a vitrified bend which enters the base of the pedestal, and is lengthened by placing a piece of tile above the bend. The space between the vitrified tile and the inside of the cast-iron pedestal is filled with Portland cement grout. The base of the pedestal beneath the sidewalk and the exposed tile as far

as the curb is enveloped entirely with concrete. Fig. 4 illustrates the above method of construction, and Fig. 5 shows the construction of the lamp posts.

The most difficult part of the work was in locating and avoiding underground obstructions. Test wells were sunk at various points, but often failed to indicate obstructions. In one case, for example, when three wells in one street showed no obstruction, a large water main was found,

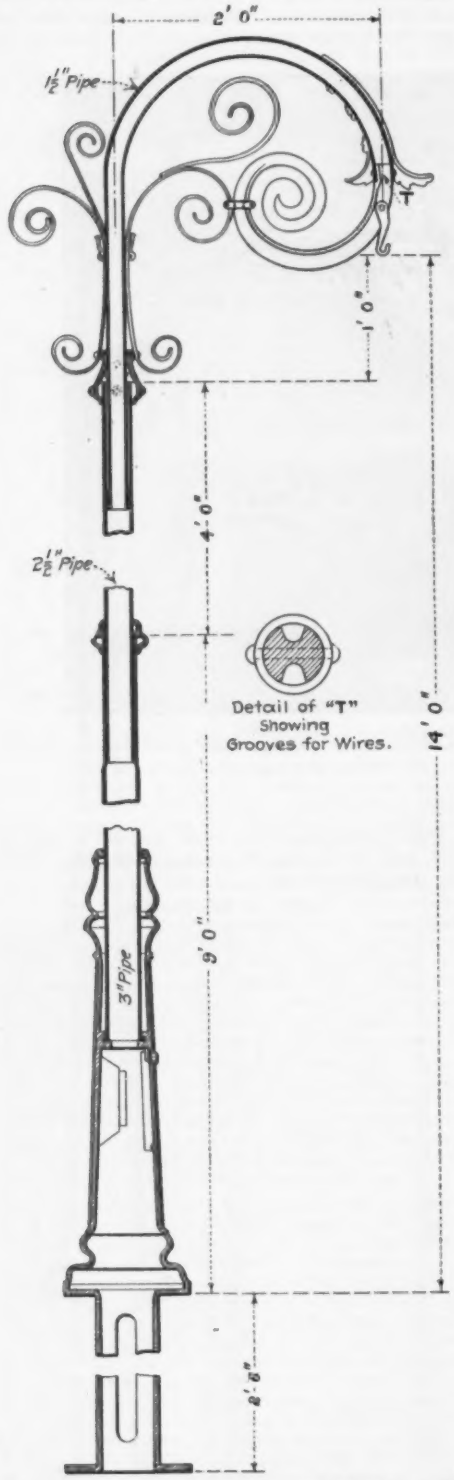


Fig. 4. Lamp Post for Arc Lamps; Cincinnati Gas & Electric Light Co.

which did not run straight along the street, but curved from side to side. The conduit had to be sunk to pass under this. These obstructions necessitated much special work. The contractors were allowed to shift sewer manholes and the house connections of water mains, but were not allowed by the city to disturb sewers or water mains except in special cases. Sewer manholes and catch basins were often removed or altered so as to permit the passage of ducts, and where fire cisterns were encountered they were often passed through. Fig. 6 shows the method of construction adopted in passing through the cisterns, the conduit being carried on a steel I-beam. The beams, before being put in place, were given two coats of asphalt, and upon the I-beams the ducts were laid in the channel formed by the two flanges, upon a bed of Portland cement mortar. The mortar was brought up on the sides of the tile and over the top, as indicated, so as to insure a water-tight joint. Many catch-basin drains were either lowered or changed in direction by consent of the City Engineer, and thereby much excavation was saved, which would have been necessary had the ducts passed beneath the drains in their old position, and thereby gave a straight

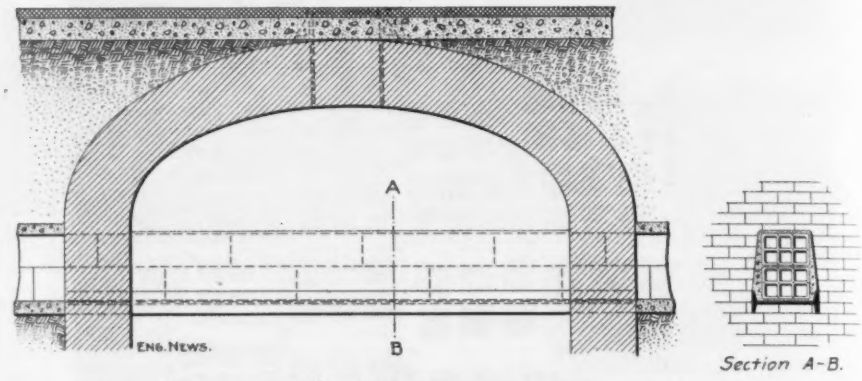


FIG. 5. METHOD OF CARRYING CONDUIT THROUGH CISTERN.

line for the conduit system. This arrangement also effected a saving in the depth of service boxes.

The standard service box was specified to be 20 × 20 × 13 ins., although the majority of the boxes exceeded this size; some were 4 × 4 × 6 ft. in the clear, and one service box 2½ ft. square was 8 ft. deep in the clear. In some cases the conditions were considered by the engineers of the company such as to require service boxes as large as a standard manhole. Service boxes and manholes were constructed on a Portland cement concrete foundation 6 ins. thick, which was given a finishing coat of Portland cement mortar 1 in. thick. Service-box walls in general were 9 ins. thick, and manhole walls 13 ins. thick. The brick were laid in Portland cement mortar and the exterior of brick walls was given a ½-in. coat of Portland cement mortar. The roofs of service boxes in most cases were formed by the cast-iron cover, although in quite a number of instances in the larger service boxes the roofs were constructed on lines similar to the roofs of the manholes. The cast-iron cover consisted of a frame, outside lid, inside lid and bar. The inside lid rested upon a lead gasket and when securely fastened by the bar was rendered water-tight.

Manholes in general were 7 × 7 × 7 ft. or 5 × 5 × 6½ ft., and their roofs were formed of Portland cement concrete and steel I-beams, as indicated in Fig. 7. Each manhole 5 × 5 × 6½ ft. required two 10-in., 25½-lb. I-beams 6 ft. 10 ins. long, four 5-in. 12-lb. I-beams 2 ft. 8 ins. long, and four ½-in. bearing plates 10 × 10 ins., making a total of 536.5 lbs. of structural steel. This roof contained 1.15 cu. yds. of Portland cement concrete. The manhole 7 × 7 × 7 ft. required 759.68 lbs. of structural steel, and 2.44 cu. yds. of concrete. The manhole covers contained no inside lid. The outside lids were perforated, and each manhole was connected with the sewer by a Gest patent sewer trap.

Many manholes varied from standard sizes, and some of the most striking examples are noted below. At Central Ave. and Charles St., at the junction of the 150-duct and 137-duct runs, a manhole 10.5 × 11.9 ft., and 8.5 ft. deep, was built to accommodate these very large runs. There was used in the roof of this manhole 4,313 lbs. of structural steel, and 6.8 cu. yds. of concrete. At Genesee and Central Aves., a large sewer was encountered, and a manhole 9.25 × 21.33 ft. and 10.8 ft. deep was rendered necessary. A concrete foundation was constructed so as to support the large sewer which crosses the manhole. The roof of this manhole was built in the same manner as for standard holes, and contained 4,675.29 lbs. of structural steel and 11 cu. yds. of concrete. At Central Ave. and N. Court St. a manhole placed at the junction of 137-duct run, 113-duct run and a 24-duct run was 7 × 11.5 ft. and 9.62 ft. in depth. At South Court St. and Central Ave., at the junction of three runs of 113 ducts, 90 ducts and 23 ducts, a manhole 7.5 × 9.5 ft. and 10.8 ft. deep was built.

Many existing manholes of old systems were enlarged so as to take in the new ducts, and in most of these places all that was required was to remove one wall and extend the manhole in the required direction. Additional I-beams were placed for the roof and concrete filling put in place. In but two cases was it necessary to remove the old roof. In many places the original location of the new runs were changed from what was originally intended so as to enter these manholes, thereby rendering new manholes at these places unnecessary.

The work was begun in March, 1902, and completed in September, 1902, occupying a period of

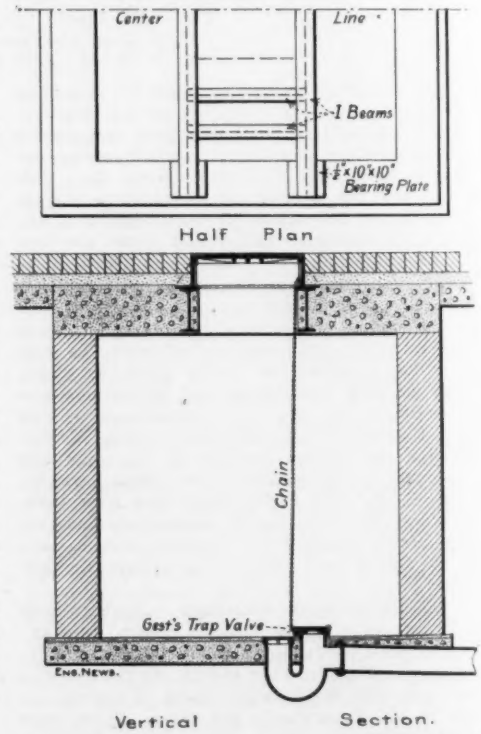
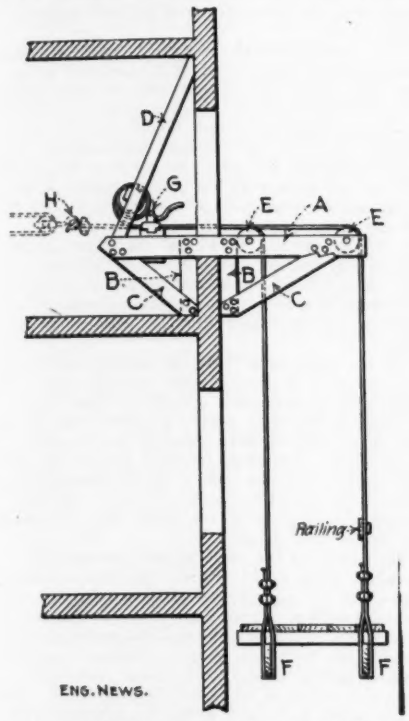


Fig. 6. Standard Manhole Construction on Electric Conduits; Cincinnati Gas & Electric Light Co.

about seven months. All work was done to the lines and levels given by the engineers of the company. Work was commenced at the four corners of the underground district by four divisions, each consisting of a division superintendent, timekeeper, two foremen on excavation, and a foreman each on concreting, tile laying, backfilling, repaving and team crew. One of the foremen on excavation was in charge of the main trench, the other foreman having charge of runs on side

streets. The concrete crew did all concrete work, such as bed for the conduit, conduit covering, street foundation, manhole foundation and manhole roof. The crew in charge of backfilling refilled the trenches, drew out sheeting and other work in this line. The paving crew did all work in connection with repaving, such as cleaning joints, cleaning brick or granite blocks, repaving, etc. The team crew attended to moving the numerous tools, bridges, sheeting, material, etc., in addition to hauling all surplus earth and rubbish



Suspended Platforms for Use in Building Construction.
Wm. H. Ellis, Cincinnati, O., Inventor.

to the dump. This latter gang was expected to see that the street was entirely clear of any surplus material of any kind after being left by it. Each division therefore consisted of several crews who had special work outlined for them. There was also detailed a foreman with several men to go over the entire work every afternoon and barricade and bridge the excavation. A very small number of accidents occurred during the entire progress of the work, which is proof that the expense incurred in looking after the work in this manner was not lost. Each division had a tool wagon in charge of a tool man, who made the rounds frequently to see if any tools were left on the work. With the tool wagon there was also a blacksmith and helper, who repaired and repointed all tools as required. As a matter of course each division had night watchmen, whose duties were to see that all danger signals were kept lighted and to see that the barricades were undisturbed, as well as to guard the contractor's property.

The four division superintendents were under the direction of a general superintendent. A material clerk had charge of all matters pertaining to material, and saw that material was ordered, received and distributed upon the various divisions. Many cars of different materials were received each day, and this branch of the work required the entire attention of the clerk in charge. Each division timekeeper, upon order of the division superintendent, made requisition for material needed.

In order to show the progress of the work, a large map of the district was prepared and mounted on a board. On this were marked the lines of conduits, manholes, service boxes, etc. Pins with tags indicating the various gangs were stuck in, showing where work was commenced and where the gangs were working at any time. On the tag was marked the number of the gang and the place and date of its commencing work. About 800 men were employed.

The work was carried on in an expeditious but careful manner, and during the construction of the 39 miles of conduit the work was so carefully guarded and barricaded that only two persons were injured by falling into the trench. The excavated material was thrown up at one side, and where necessary a line of planks on horses was placed to keep people away. At street intersections the trench was bridged for teams, and light portable bridges with high sides were used for pedestrians. This part of the work was subject to the supervision of the city engineer as well as the engineer for the company.

SCAFFOLD FOR USE IN FINISHING EXTERIOR BUILDING WALLS.

In setting the brick and terra cotta facing of the 16-story concrete building described in our issue of July 30, a special form of suspended scaffold or platform was used, which was the invention of Mr. Wm. H. Ellis, of W. H. Ellis & Co., the general contractors for the building. This device has been patented by Mr. Ellis, and we are indebted to him for plans and information.

The general construction is shown in the accompanying cut, and the supporting brackets and suspended platforms were clearly shown in Fig. 15 (p. 90) of the article above referred to. At the window openings of the upper part of the building are erected frames or brackets which straddle the wall. These consist of a horizontal member, A, with vertical members, B, on each side of the wall, and braces from these to the ends of the horizontal member. The inner end is secured by a brace, D, fitted against the wall. The projecting end of the frame has a pair of sheaves, E, E, for the ropes or cables which support the platform stringers, F, F. A heavy clamp, G, on the frame, holds the ropes and sustains the platform at any desired height. The platform is raised by attaching the ends of the ropes to a block and tackle, as shown by the dotted lines at H. When the hoisting tackle is ready, the clamp, G, is released, the ropes are hauled in to bring the platform to the desired position, and are then again secured by the clamp. The tackle is detached and the loose ends of the ropes are looped over a head on the frame.

The platforms are in sections, placed end to end, and are preferably kept at the same level so that they form a continuous platform across the face of the building. Railings may be fitted to provide for the safety of the men working on the platforms.

With this arrangement, no scaffolding structure around the building is required, which would interfere with the use of the street or sidewalk, and the face of the building is left clean and finished as the work progresses and the platforms are raised.

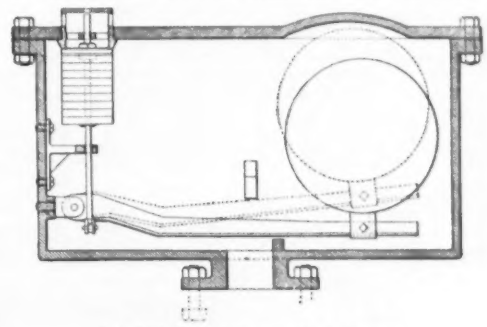
AIR RELIEF VALVES FOR PIPE LINES.

Where summits occur in water mains and pipe lines carrying water or other liquids, it is often necessary to provide relief or blow-off valves to discharge any accumulation of air or gas. The accompanying cut represents a combined float and poppet valve for this purpose, invented and patented by Mr. Arthur S. Tuttle, M. Am. Soc. C. E., of Brooklyn, N. Y., to whom we are indebted for particulars concerning it.

The device consists of a chamber fitted with one or more poppet valves and floats, or two valves for light pressure can be operated by a single float. The lever arm of the float is pivoted to a lug in the chamber, but it is not attached to the stem or spindle of the valve. When the gas or air is accumulating, the float and its arm descend until the arm strikes a pin or the spindle and pulls down the valve, opening a passage for the escape of the air. The proportions of the various parts of the mechanism are made to suit the maximum pressure, and when equilibrium is restored by the escape of the air, the float and arm rise, releasing the valve, which then closes by its own buoyancy. The spindle moves in guides, so that the valve is kept in a vertical position. Lugs or stops limit the travel of the arm.

The valve will free the main from air while it is being filled, and will also admit air in case of a break in the main, thus preventing the liability of collapse of a steel main under external pressure when the escape of water tends to create a vacuum. The valve is usually made with a 2-in. opening, and may be set directly upon a tee in a main, or with a 3-in. stop valve placed between the main and the relief valve.

The valve was designed by Mr. Tuttle in 1900 for use on a 72-in. steel pipe storm water sewer, laid in Jersey City, N. J., and discharging under pressure. This pipe was practically level for 2,100



Air Relief Valve for Pipe Lines.
Arthur S. Tuttle, M. Am. Soc. C. E., Brooklyn, N. Y., Inventor. Eddy Valve Co., Waterford, N. Y., Makers.

ft., with its invert about 5 ft. below mean low water, It received the drainage from the Heights, partly through a 50-in. cast-iron pipe. 1,500 ft. long, and partly through a 48-in. cast-iron pipe 1,600 ft. long. The speedy and certain removal of air from these mains during storms occurring when the mouth of the sewer would be sealed by the tide was absolutely essential, and we are informed that the satisfactory results given by the valve under these conditions led to its being placed upon the market. The Eddy Valve Co., of Waterford, N. Y., has acquired the right for its manufacture in this country.

STREET CLEANING IN SAN FRANCISCO.*

By L. M. King.†

The first of July witnessed the beginning of a new contract for street-cleaning. As this may be the last of such contracts, since the city contemplates doing the work next fiscal year, a resumé of the methods employed under the present system and some reasons why better work has not been done in some districts, may, perhaps, be of interest. The streets of San Francisco are cleaned by eight different processes, all of which combined go to make up the present system.

BLOCK SYSTEM.—There are 122 block men stationed throughout the principal wholesale and retail districts, each man being assigned to certain blocks, which he is responsible for keeping clean all day. All dirt on these streets is picked up and deposited in special metal dirt boxes along the sidewalk, and removed by teams in daylight. A fixed price of 90 cts. per day per 1,000 sq. yds. is paid for this work.

MACHINE SWEEPING.—Certain streets south of Market St. are swept at night by machines. The streets are first sprinkled; the dirt is then swept by the machines into the gutters, where it is gathered into piles by special men employed for this purpose, and afterward it is removed by teams before 7 a. m.; 35 cts. per 1,000 sq. yds. is paid for this.

HAND-LABOR GANGS.—All streets other than the above are cleaned by hand-labor gangs. To each gang are assigned certain streets, which it is to clean a fixed number of times each month. These gangs are to sweep the dirt into piles, which are required to be removed by teams within two hours. This work costs 25 to 39 cts. per 1,000 sq. yds. in different districts, each time the street is swept.

SPECIAL CREWS.—Owing to the prevailing winds in the residence district, it has been found that many streets have their gutters filled with dirt before the next sweeping is due, while the central portion of the street is practically clean. To increase the schedule and sweep the entire area of such streets would be a useless waste of money; and still the gutters require more frequent cleaning. This difficulty has been overcome by providing in each district for a "special crew" of three sweepers, a team and a driver, whose duty it is to go over streets scheduled for cleaning from once to four times a month, and to clean the gutters only in the interval between the regular cleanings. These special crews are one of the best features of the street-cleaning system, for besides

*From a paper in the "Merchants' Association Review."
†Superintendent Merchants' Association, San Francisco, Cal.

this gutter-cleaning, they can be used, when so directed by the Board of Public Works, to remove special accumulations, loose grouting and similar refuse in any part of the city. The special crews cost 33¼ cts. per hour for each sweeper, 39¼ cts. for foremen and 65 cts. for each team, wagon and driver.

HOLIDAY AND SUNDAY CLEANING.—On Sundays and certain holidays a crew of 14 sweepers and a foreman is provided to clean gutters and sidewalks, from 6 a. m. to 10 a. m., on Market St., from the Ferries to Larkin St., and certain streets in the neighborhood, where people congregate on such days. The cost of this is the same by the hour as paid for special crews.

CROSSWALK CLEANING.—On rainy days, when regular sweeping is suspended, a force of about 25 men is employed to clean crosswalks and sidewalks on the business thoroughfares most frequented by pedestrians. The cost of this work is the same as for special crews.

WASTE PAPER CLEANING.—A horse, cart and driver are provided during the windy season to cover those points in the city where loose papers accumulate. These papers are picked up and removed at intervals during the day, and the cost of the service is 50 cts. per hour for the outfit.

STREET FLUSHING.—The bituminous rock pavement on Market St. in wet weather frequently becomes covered with a slippery coat of mud, which cannot be removed by brooms, and causes many horses to fall. To overcome this a system of flushing is used. Two or three sprinkling carts with open flanges flush the streets thoroughly, thus loosening the coating of mud. Following the carts is a gang of sweepers, who scrape the pavement with rubber squeegees. Bituminous rock and asphalt pavements are not slippery when thoroughly wet if the pavement itself is clean, and this flushing has been found very effective in reducing slipperiness. The cost is $1 per hour for each sprinkling cart, including water.

RESULTS OF THE SYSTEM.—The above comprises the system of street-cleaning, as devised by the Merchants' Association for San Francisco. The system is good and complete. If followed strictly, the streets will be well cleaned. It happens, however, that contractors as a rule are liable to become careless and do no better work than they are obliged to do. Rigid inspection by the City Inspector, accompanied by prompt rejection or fines for poor work, is necessary to secure good results. It is no easy matter to inspect properly the street cleaning here. There are over 200 miles of paved streets in the city, and besides the "block" men there are twelve gangs of men working simultaneously in all portions of the city during the day time, in addition to the machines at night. Only two inspectors are employed to examine all this work and see that the specifications are complied with.

The principal defect has been the lack of sufficiently heavy sprinkling to prevent the raising of dust. It is sometimes difficult to get drivers of sprinkling carts to use good judgment as to the quantity of water to be used on days of varying temperature and wind.

The machine work for a number of months has been good for work of that kind on such pavements as are found on many streets south of Market St. Our rough pavements require heavy machines with brushes having long rattans. One of the parts of the machine work that is most often improperly performed is the cleaning up of the piles of dirt in the gutters. Drivers are apt to try to clean these piles up with the shovel alone and not use a broom to brush up the remnants of piles. This leaves the gutters in an unsightly condition and the contractor is liable to a fine of 50 cts. for each block or crossing upon which such remnants are left.

Much of the work of the outside hand-labor gangs during the last two or three years has been bad. It should be much better than machine work, but, as a matter of fact, it has been worse. For this there is absolutely no excuse. There is a limit to the degree to which a rough pavement can be cleaned by machines, and nothing more can be expected, but there is no limit as to how well a basalt or cobble pavement can be cleaned by hand-labor, except the natural grouting in the joints. It has been an everyday occurrence to see basalt and cobble paved streets which had simply had the refuse swept off the tops of the stones, and showed no effort whatever to sweep the loose manure and refuse out of the joints. This is caused by the desire to cover as much ground as possible in a day and because the foreman of the gang, who is also a sweeper, pays little attention to how his men sweep.

A STANDARD CULVERT FOR NEW YORK STATE HIGHWAYS.

While cast-iron and vitrified pipe culverts are very largely used on the road construction under the New York State Engineer and Surveyor, it is customary to specify concrete or stone box culverts where pipes of moderate diameter will not carry the water. The design of masonry box culvert shown in Fig. 1 may be said to be a growth, the newest feature of which is the use of concrete cover blocks in place of flag stone. These cover blocks, Fig. 2, are reinforced with expanded metal, and make a cheap and efficient substitute for flags. We have selected this particular design of culvert for illustration principally because it seems to us to be cheaper than a stone or concrete arch and more readily built. For, wherever an arch is to be used, centers have to be made, and heavy abutments must be provided to resist the lateral thrust. Both on the centers and the abutments there is an expenditure of labor and materials seldom justified where the span of the arch is slight. Moreover, in roadwork where embankments are seldom high, there is not the head room for an arch culvert that is usually to be found in railway work; and if the engineer designs a flat arch the thrust on the abutments is made correspondingly greater. A box culvert of the type shown in Fig. 1 is quickly built, where stone is available for the side walls, without the necessity of making centers or forms of any kind. Its walls are light, and by the use of concrete and steel for the binding, spans of considerable length can be put up at low cost. The concrete slabs, moreover, can be made at some convenient point and hauled to place, thus reducing the cost and trouble of inspection.

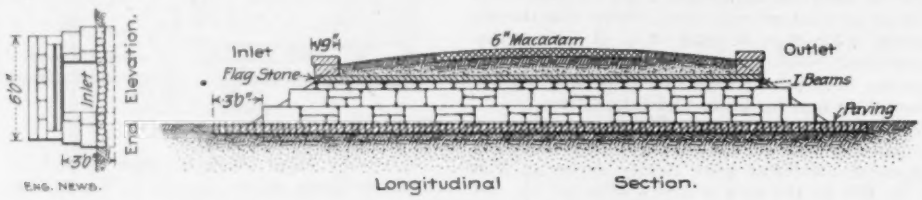


FIG. 1. A STANDARD BOX CULVERT, N. Y. STATE HIGHWAYS.

In the early days of macadam roadwork in New York State it was the practice to bury one or more cast-iron pipes under each driveway or crossroad. One 12-ft. pipe was found to make a rather narrow driveway, especially at night when in turning off the main road to enter his private roadway the farmer was apt to suddenly find one or more wheels in the ditch. It is idle to argue with a driver about being more careful in future, or to suggest that "corn juice" may have had its influence in upsetting his vehicle. Two 12-ft. pipes with masonry head walls were demanded, and were very generally supplied. This meant almost a ton of cast iron for every private driveway along the road, which in suburban sections lead to an expenditure of several hundred dollars a mile for "farm crossings" alone. One solution of this problem is shown in Fig. 3, which is a design for a plank bridge crossing. Another solution of this same problem has been suggested, and that is the entire abolition of deep ditches in suburban road building, giving the roadway the cross-section of a village street. Not only are deep ditches unsightly, but they are very seldom needed. In the few places where they are needed the crossing shown in Fig. 3 is a satisfactory solution of the problem, so far as first cost is concerned—and first cost should certainly be given consideration where so many thousands of miles of paved roads remain to be built.

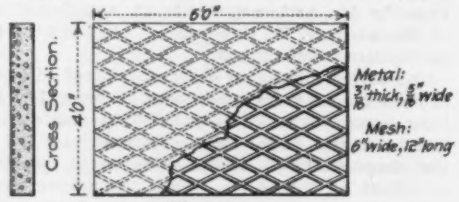


Fig. 2. Reinforced Concrete Cover-Block.

SOME THEORIES UPON RAILROAD LOCATION.*

By J. G. G. Kerry, A. M. Can. Soc. C. E.

Railway location is again becoming one of the most important branches of civil engineering in Canada, partly because Canada is entering an era of railway construction unequalled in magnitude by any that it has passed through since the completion of the Canadian Pacific Ry. main line in 1885, and partly because the critical study of railroad transportation, commenced, in engineering departments at least, after the publication of the revised edition of Wellington's "Economic Theory of Railroad Location" in 1891, has established principles which call for the almost complete reconstruction of the more important of the older lines.

The general route of a railway is rarely determined by engineering considerations. The promoters of the line—be they politicians, railroad men, or speculators—have some political or financial end to attain, and to that end all other considerations will be subordinated. It has frequently happened that the route has been determined before an engineer has even been called in for consultation, and in easy country such a practice cannot be considered altogether objectionable. An engineer's training does not fit him in particular, as distinguished from other classes of railway officials, to foresee the great economic and commercial changes that will be sure to follow the opening up of railroad communication, and at times he would be almost at a loss to choose between competitive routes, had they to be judged from an engineering standpoint only.

On the other hand, instances are not unknown where the promoters have undertaken to locate a line through what is by no means easy country, and the history of such attempts is the most forcible argument that an engineer can bring forward when opposing any repetition of the same policy. The writer conceives it to be the duty of a chief engineer to form and express an independent opinion upon the merits of any route that he is instructed to examine, the adoption of the route being a question for his employers to decide.

The growth of the great railroad systems will, in part, save the lines of the future from those curious deviations, due to the influence of local subsidies or to the personal feelings of promoters, that are a feature of many of the older locations. The fact that a line that has been located and built can never be rebuilt on a better line without serious difficulty and expense, and in many cases cannot be rebuilt at all, is not always realized. There are many places in Canada where the forgotten quarrels or friendships of long years ago have left a permanent record of their occurrence in the shape of an inferior line. Such a place will be found on the old Midland Ry. in the township of Mara, where the company decided, as the result of a subsidy quarrel, to avoid every village in the township and to open no stations within it. The policy was carried out, but in time an agreement as to subsidies and stations was reached, and the quarrel forgotten. Its record remains in lonely stations and a ruined grade line.

Making an exception of those numerous lines which have been built in Canada for the purpose of opening up new regions for settlement, and whose very existence is due to public liberality, it may be said that all railways are built as business concerns to transport passengers and freight, and that the share of the business offering that they secure is a fair measure of their success. There have been many bankrupt lines in Canada on account of lack of traffic; there can be none that will succeed without it, and every effort should be made to secure it where it exists and to create it where it is lacking.

The control of through traffic is hardly affected by the details of location. It is a question of terminals and alliances, and lies within the special province of the general manager or president. It may be advisable to modify the general route to secure such traffic, it certainly will be worth while to reduce the grade line in order to handle it; but it is wise to recognize that it may be entirely cut off from even a powerful system. For example, the extension of the Intercolonial Railway from Levis (Quebec) to St. Hyacinthe (for Montreal) transferred all its traffic from the Quebec branch of the Grand Trunk Ry. to its own new lines.

Fig. 3. Plank Bridge for Ditch Crossing.

A notable example of a series of lines that have failed to secure the through traffic which they were planned to handle is found in several of the "Portage Roads" between Lake Huron and Lake Ontario. They all hoped to carry a heavy share of the east-bound grain business, and no skill of the locating engineer could have affected the final result. Their failure is to be ascribed to their own financial weakness and consequent inefficiency, and to their inability to recognize the control that established interests have over any trade. They might have had

*Abstract of a paper read before the Canadian Society of Civil Engineers.

some success had they been a part of a thoroughly organized through system and backed by powerful grain shipping interests. Being but one link in an unorganized system they failed. The desirability of adding yet another to their number by building the "National Transportation Route" between Collingwood and Toronto is often urged at the present time. It seems to the writer that this line, no matter how skilfully built, will prove an utter failure unless it is but part of a vast lake, rail and river transportation system under one management. In any case he is frankly doubtful of the ability of the present St. Lawrence Canal system to hold its own against railroad competition.

Much of the railway line now projected will run through practically unsettled districts, and it may be safely predicted that the situation of the future centers of population that will control local trade will be determined by the presence of natural resources, and by the location of the railway. It follows that the more nearly these two causes can be brought together the better it will be for the future of both country and railway. It is not easy in preliminary survey to recognize the existence of the natural resources, nor to realize how great their future development may be. The location engineer, indeed, gets but few opportunities to observe the growth of traffic on the lines that he has planned; but he should certainly know what staples constitute the bulk of the traffic in adjoining districts, and why they are produced there. The location of the Great Northern in Quebec is a recent example of a line avowedly laid out to approach as nearly as possible to the great Laurentian water powers, which were considered to have the greatest traffic producing possibilities of all the resources in the district.

In eastern Canada the commercial centers are well established, and practically all traffic originates near them. Any effort to ignore these existing centers will result in the material disadvantage of both town and railroad; the town will be handicapped in its commercial growth and the railway will lose the business that would have been created. The locations of 50 years ago are full of efforts of this kind, made, it is said, largely in the hope of inducing the town to move on to land in the immediate vicinity of the railway station, and owned by the railway promoters. The series of towns along the north shore of Lake Ontario, between Toronto and Kingston, are proof of the inability of a railway company to compel an eastern town to move; they still stand where they stood 50 years ago when the railway was built past them.

Brantford, Ont., has furnished the most remarkable example of the power of an established town to hold its own against a railway company. The Great Western Ry. passed it by about 1850, when it had a population of 3,877, and located through its rival, Paris, which had a population of 1,800, the final choice having been influenced, it is said, by a subsidy. To-day, after over 50 years of struggle, Brantford has at last succeeded in getting the main line traffic of the old Great Western Ry. diverted into it, and in spite of transportation difficulties, has grown into a city of over 16,000 inhabitants, one of the most active manufacturing centers in Canada.

It may therefore be taken as good practice in eastern Canada to carry the location directly into the existing towns, no matter how great may be the cost of right of way or the sacrifice of engineering niceties, for the return will in nearly every case give ample profit on the expenditure. In exceptional cases it may be necessary to construct a freight loop around the town if too serious a sacrifice of grade would otherwise be required, but by the use of momentum freight can be carried directly through a town situated in a hollow. The Canadian Pacific Ry. line into Lachute has 1% falling grades on each side of the town, and runs its traffic straight through without stopping, unless there is local business to be attended to.

PRELIMINARY WORK.

Maps and local knowledge are the two first things to be secured in the equipment of a survey party. Where accurate maps cannot be obtained, there is no source of information of more general value than the men who have worked for long periods in the district, and have had years in which to learn what the engineer is usually expected to acquire in a few weeks. The knowledge that they possess may not be such as to be immediately applicable to the problem of selecting a line; but the first duty of an engineer is to get thoroughly acquainted with the general topography of the district, and by availing himself of the services of the local men and by exploring with the assistance of such minor instruments as the hand level, the aneroid barometer, and the pocket compass he can accomplish this speedily.

It is to be remembered that the great engineering errors in railway location are made in most cases before the instrumental surveys are even started, and that the more widely the preliminary explorations are extended, and the more completely all local sources of information are utilized, the better will the engineer be fitted to deal with the problem that he has been given to solve. The policy now adopted by some Canadian lines of keeping small reconnoissance parties in the field to work up information requisite for future locations is admirable practice, the value of the result being, however, in direct proportion to the character of the men employed, for there is no task that calls for more steady thoroughgoing, conscientious hard work than the complete exploration of any piece of country. Exploration should never be regarded as complete until the engineer is able to select the route along which his detail surveys will be made.

When the exploration has been completed, location becomes a problem of detail surveying, in which the necessity of reducing first cost to a minimum has to be constantly balanced against the demands of the operating departments for a straight and level track. Surveys with instruments of precision are necessary to adjust the alinement so nicely to the local contour that no stretches of track will be built over which rolling stock cannot be advantageously operated; and the area that can be covered by a precision survey is so limited that nothing but this local adjustment should be expected from it.

OPERATING CONDITIONS.

In the "Economic Theory of Railroad Location," the variation of operating costs with train mileage was made the base of all calculations; and although the systematic studies now made by the audit and statistical departments show that train mile cost is not the same for trains in dissimilar service, the heavy freight traffic is of such preponderating importance to Canadian railways that increase of train-load can be accepted as proof of improvement in operating.

That the most efficient railway is the one whose line and motive power are best adjusted to each other is the lesson of modern operating, but before considering how this adjustment should be made, it will be well to notice the great development in rolling stock that has taken place since the days of the Canadian Pacific Ry. surveys. The specifications of about 1885 called for the use of rolling loads, consisting of engines weighing 110,000 lbs., followed by 3,000 lbs. per lin. ft.; those of to-day require engines of 225,000 lbs., followed by 5,000 lbs, per lin. ft.

The modern car for heavy ore and coal traffic has a nominal capacity of 100,000 lbs. and a weight of about 36,000 lbs. Remembering that it is not unusual to overload these cars, and that some of them are not above 30 ft. in length, it will be seen that the extra heavy specification of to-day is not in advance of the extremes of present practice, and that weights as high as 40,000 lbs. are sometimes concentrated on a single car axle. These ore cars are, however, somewhat exceptional, and for regular freight traffic cars of 60,000 lbs. capacity, with weights slightly over 30,000 lbs., are most common.

During an extensive discussion before the New York Railroad Clubs in November, 1901, Mr. Vauclain stated that a load of 45,000 lbs. per axle might be considered the limit of good locomotive practice at that date, and although in special cases it has been exceeded, there are but few engines in service on the continent to-day with axle loads exceeding 50,000 lbs. In Canadian practice the maximum axle loads vary from 45,000 to 50,000 lbs. on the various roads, the heaviest loadings being found on engines of the ten wheel and mogul types.

It has often been stated that the increase of rolling stock weights must very soon cease, and as often the prediction has proved to be entirely wrong. There are some facts that to-day point to at least a temporary suspension in this increase. These are the establishment of a standard box-car, the proved difficulty in economically handling trains more than 70 cars in length, and the difficulty of obtaining satisfactory rails to use under existing rolling stock.

Almost any piece of Canadian line is likely, owing to the free movement of cars, to be subjected at any time to the maximum carloads mentioned, unless special action is taken by the operating department to protect lines that are unsafe under such loadings. The heavy grade lines to the east of Montreal will cause the very heaviest classes of locomotives to be introduced on our roads as the traffic increases, and the location engineer must therefore recognize that his line may be subjected to the heaviest loadings that the practice of the future will sanction.

MOMENTUM GRADES.

The safety of using "momentum grades" in location is one of the disputed points of present practice. Comparing "momentum" with locomotive tractive power, it may be said that tractive power is directly dependent upon the condition of the engine and the skill of its crew, and will often be much below its calculated value, and that momentum is equally uncertain if the velocity which is essential to its existence is obtained from surplus engine power. Momentum which is obtained by the action of gravity is the most dependable of mechanical forces. The use of momentum grades is universal in operating practice. As a case in point, the Lachute example, already referred to, may be quoted, or the action of the Grand Trunk Ry. in moving Gananoque Junction about 1½ miles eastward in order to place it at the top of a long up-grade, which included a stretch of grade of 50 ft. per mile.

The possibilities of using momentum to advantage are greatly limited by topographical conditions. As already remarked, it gives no assistance at the upper end of long grades, and the use of short, sharp grades is limited by the necessity of changing the rate of grade slowly at summit and hollow, which will sometimes altogether prevent their introduction. Its assistance can be gained only at the price of reduced speed, which may be undesirable where fast service is necessary, and there is always an uncertainty as to the continued existence of the conditions which make the required velocity of approach a posibility. The necessary control of speed due to features of the existing track, the demands for new stations and sidings by future industrial development, and the establishment of level road on railroad crossings may at any time render momentum operation impossible. During the past year the Railway Committee, in one instance, sanctioned the putting in of a level railroad crossing across a line carrying one of the fastest and most important passenger traffics in Canada, and in the very center of a long grade averaging 35 ft. to the mile. This example (the crossing of the Grand Trunk Ry. by the Aurora & Schomberg Ry.) indicates very clearly the caution that should be observed in planning momentum grades.

When used, they should be introduced as close as possible to the foot of the hill, and there seems no strong objection to rates of grade as steep as the pusher equivalent of the ruling grade. A stalled train cannot be divided into fewer than two parts, and for certainty of operation a doubling siding should be placed at the head of every serious momentum grade.

The writer is of opinion that railway practice sanctions the use of momentum wherever thorough surveys have demonstrated the impossibility of securing a direct line without it. He knows no district naturally more adapted for its use than the country lying to the north of Lake Ontario and to the east of Toronto, and there its free application would probably result in shorter and more direct lines. In practice, many cases occur where the raising of a grade line by but a few feet would result in great economy, and in such instances it would seem folly to refuse to make use of momentum to gain those feet.

RULING GRADE.

The theory that minimum train mileage will result in maximum economy of operation is, as has been said, generally accepted as the working maxim of present day operating. The importance of the rate of the ruling grade is easily understood when it is realized that grade resistance is about two-thirds of the total train resistance on many Canadian lines, and as the locomotive cannot exert more than a certain maximum pull, the train mileage necessary to move a given tonnage is proportionately increased.

The selection of the ruling grade to be used is the most important technical problem to be settled by the surveys. It is exceedingly difficult to reduce it below the rate of the general rise of the country except by developments, the economy of which in many cases may be questioned, and the practice of laying down the ruling grade before the topography of the line has been studied is capable of little defence; in the past it has resulted in far too free use of the maximum. Wellington's claim that the ruling grades of many lines could have been reduced by one half without material increase of cost is perfectly correct as regards some of the older Canadian lines.

It must be recognized that the economic effect of grade reduction can, and daily is being secured by increase of motive power, and that in general it will be cheaper to attain that effect by the latter method than by attempting to reduce the grade beyond the limit that the ground sets. Abrupt rises, such as the Niagara escarpment, which occur perhaps but once in the length of a line, must be overcome either by developments or by pusher grades. For heavy traffic, where the pusher engines can be kept fully occupied, the latter is preferable, and on light traffic lines its equivalent can be secured by the use of doubling tracks. The writer knows one instance where a ruling grade of 30 ft. to the mile was secured by a development involving an increase of 0.9 mile in a distance of 2½ miles, as well as an increase of about 140° curvature and two railway grade crossings. This line was intended to be as perfect as engineering skill could make it, and yet all the above difficulties could have been avoided by the use of a grade of 53 ft. to the mile, at a point where abundance of motive power was always available. It is not to be concluded that pusher grades are always better than developments, but only that both methods, and the advances they have in connection with the local topography, should be studied. The use of the ruling grade should always be avoided when possible.

CURVATURE.

In railway economics but little advantage is shown to result from reduction of curvature. There is, however, no doubt, that it is received with general approval by all employees connected with the operating department, and that it will become even more popular as train speeds and weights of rolling stock increase. As already noted, train resistance is materially increased by curvature, and compensation by grade reduction must therefore be made on all ruling grades, and preferably on all heavy grades. On account of the known increase of this resistance with bad condition of track and rolling stock, the compensation should be liberal, and should be carried out to the ends of the transition curves. The effect of curvature in increasing starting resistances is not known, but very strong objection to stalling on a curve exists among train hands. The maximum degree of curve to be used should, like the ruling grade, be determined by the local topography, the

demand for easy curvature being mainly from high speed traffic, a variety which occupies far more space in the public and the railroad mind than its financial importance seems to warrant. In Eastern Canada there seems but little need of curvature sharper than 4°.

GRADES AT YARDS.

The increase of running resistance at starting also must be compensated for. Important yards really form a special location study in themselves, but minor yards are much alike in design, and can be treated in a general way. The running resistance is increased by about 2 lbs. by temporary stops, and by from 6 to 10 lbs. by prolonged ones. Assuming the upper limit as the safer in practice, and making an allowance for the extra power a locomotive can exert at low speeds, the formula for yard grade would be

$$\frac{7}{6}\left(5 \times 2{,}000\,\frac{Fr}{100}\right) = 15 \times 2{,}000\,\frac{Fy}{100}. \qquad (9)$$

Fr and Fy being the rise of ruling and yard grades respectively in feet per 100, and 5 and 15 the track and yard running resistances in lbs. per ton. Where sand is used, and with compound engines working simple, less compensation will be required. The equation given is unsatisfactory, in that it makes no allowance for the powerful assistance that may be obtained from the springs in the draft gear, and it is noteworthy that in the Burlington tests in 1887 the trains always started with this assistance, and stalled after moving a short distance. Practically a level yard is the most desirable, and when it cannot be obtained, a grade reduction of at least 0.5% should be tried for. The flattened grade should be continued for such a distance that the train can acquire a speed of 5 miles per hour, this being the speed at which most of extra running resistance will be found to have disappeared. The running resistance averages about 7 lbs. up to this speed, and the distance is given by the formula

$$\left(5 \times 2{,}000 \times \frac{Fr}{100}\right) d$$

$$= \left(7 + 2{,}000\,\frac{Fy}{100}\right) d + 0.0355 \times 2{,}000 \times S^2 \qquad (10)$$

It is desirable that the train should acquire speed rapidly, and therefore the grade leaving the yard should be as low as possible, and at least such that it will be about 3 ft. below a ruling grade, drawn from a point half a train length back of the point last determined.

At the lower end of the yard it may be desirable to use a short length of sharpened grade, in order that the main yard can more easily be made level. Such a grade will act simply as a permanent brake, and its length and rise should be adjusted to the assured velocity of approach. There are comparatively few stopping points to be provided for on any line, and the adjustment of the grades to and from them to suit theoretical considerations should not prove excessively costly.

GENERAL CONSIDERATIONS.

When the limits of grade and curvature have been fixed, railway location becomes little more than the solution by survey of a series of problems, in each of which the operating economy of lowered summits, reduced curvature, and shortened distance has to be balanced against the cost, as shown by the surveys and estimates, of making these improvements. The proper figures to use in calculating operating economy are very difficult to determine, and the values given by Wellington are still generally accepted in practice in spite of the great advancement that has been made in operating methods during the last ten years. The train mileage, upon which all economic calculations are based, is itself so uncertain a quantity that there is no special advantage in having very close values determined by the saving resulting from unit improvements in grade and curvature and distance. The striking feature of the minor eastern Canadian lines is the very slight tendency to increase shown by their traffic returns, a feature which calls for decided caution in traffic estimates.

In the future the skill of the engineer will be less hampered by financial necessity than it has been in the past. That minor lines are in themselves unremunerative is generally recognized, and the construction of the class of lines that formerly depended upon the future and upon local assistance for financial resources has become almost an impossibility. The backing of one of the great systems, or very liberal public subsidy, is essential to the successful carrying out of these minor enterprises, and the current of public opinion is certainly setting against subsidies, except for the opening up of new districts. In establishing their own branches, the great systems will feel no imperative necessity for an economy that can be measured by units no greater than thousands of dollars, and will be willing that the roadbed, in common with the track and the rolling stock, shall become a subject of more liberal expenditure. Grading does not to-day constitute nearly so large a proportion of railway cost as it did 20 years ago.

As a general principle, the writer would consider it good practice to assume that a proposed line will eventually carry a heavy traffic and to make the location accordingly. By the use of cheap structures, and by the introduction of temporary grades and curvature, the cost of construction can be greatly reduced, and the line left in excellent shape for improvement when the traffic shall have developed. It should be generally recognized that the executive department of a railway will sanction a scheme for improving an existing line in preference to one that involves a new location, the legal and land difficulties that are involved in the latter case being almost entirely avoided in the former. The calculations of the economies resulting from detail improvements cannot be made with sufficient accuracy to justify an engineer in accepting their indications except in the most general way; and where the resulting gain shows but a small margin over the cost, the improvement may safely be left to the future.

Operating details, whose importance has not yet been measured by the science of economics, should also be considered during location. Of these the need of ample yard room is the most important. In the present great rush of traffic, it has proved much more difficult to keep the yards clear than to keep the lines open, and there is probably no railway to-day that is not carrying out great yard extensions. It is difficult to foresee during location where the demand for yard space will be made, and perhaps the most satisfactory provision for the future that the locating engineer can make is the selection of ample areas of level ground in the vicinity of all important centers, and preferably where a level grade and a straight alinement can be obtained. There are few yards to-day on the older lines which are not surrounded by settled districts that have grown up since the establishment of the yard, and the cost of extending these yards is made almost prohibitive by land values. It may be noted that the number of important divisional yards is likely to decrease in the future, as there is a decided tendency to extend the lengths of the train runs, division of 150 to 160 miles being operated, where formerly 100 to 120 miles would have been considered a maximum length.

Every effort should be made to avoid road and railway grade crossing, swing bridges, and lines along public streets, not only because of construction cost, but particularly to secure freedom of traffic movement.

Snow removal will be a perennial source of expense to Canadian roads, and its accumulation should be prevented by location if possible. It is customary to elevate the grade two or more feet above fields and flats, in order that the rail may be always windswept. In cuts, ample width should be provided, and the rail raised well above the bottom of the cut wherever the wind directions are such that serious drifts will be formed. In bush location, the change of snow movement that will be caused by clearing should not be overlooked.

That satisfactory track is largely a question of thorough drainage has long been acknowledged, but the fact that the necessity for drainage is a matter of natural soil has not been as clearly recognized by the railway engineer as by the common road builder. Cases occur where an inexpensive shift of the line would throw it upon a dry and open subsoil, and after the drainage conditions completely.

The necessity of securing a good foundation for the roadbed is a point that should not be overlooked, as that detail affects both construction and operation. Every soft spot should be thoroughly tested before the location is finally laid down, and if any great depth of weak material is discovered, the line should be changed so as to avoid it. The writer knows of at least one serious sink-hole over which the original location and construction was carried without any investigation. Bad foundation is not only a construction danger, but will be found to be the cause of a wave motion, when under traffic, that materially increases the tractive effort required, and renders it extremely difficult to maintain the track in good condition.

It would appear superfluous to remark on the necessity of always considering construction during location, were it not that many locations are made which require material alteration before the line can be built. It may be said that no engineer who has not had previous experience in location, construction and operation is capable of making a first-class location. There is unfortunately no line of work in which the best workmanship is more likely to escape general observation, an appreciation of which fact is perhaps the reason that so many capable railroad engineers have taken up other branches of their profession.

A notable case occurred on the extension of the B. & O. lines northward down the Monongahela Valley from Morgantown, West Va. The river is subject to great floods, and it was considered necessary to keep the grade line well above flood level, the location being made a short distance up on the side hills of the valley. In places the profile showed a succession of short, sharp cuttings through points running out from the main hill. The material in these cuttings was in reality nothing but the debris of forgotten slides, but this was not noticed either by the location or the construction engineers. When the winter came every slide started to move again, as its supports had been cut through, and a heavy yardage of most difficult material had to be removed from the finished roadbed. On another West Virginia road it was found necessary to relocate some miles of the line, because it was fitted so closely to the contours of the side hill that it would have been impracticable to obtain a full width roadbed, although the center line showed an excellent profile. In a minor degree, it will be found possible to shift many locations, so as to materially reduce the cost of construction, either by obtaining a smaller yardage or by locating through material that can be more easily handled. Mistakes in not taking advantage of the nature of the ground are particularly likely to occur on lines that are being located by contour plan.

It may be said that every district has its own peculiarities, and that if the engineer does not spend some time in studying the characteristics of the local material, he is bound to make some serious errors in his location, the results of which will be generally set down to unavoidable natural causes.

MUNICIPAL AND MILITARY ACETYLENE GAS PLANTS.*

By J. F. Tilley, Jr.†

The municipal acetylene plant at Manchester, Va., was started June 9, and completed Aug. 15, 1900. It consists of 21,331 ft. of 2-in. pipe, 4,679 ft. of 4-in. pipe and about 5,000 ft. of 1-in. and ¾-in. pipe. The Williamson non-automatic system of generation is used, backed up with a 5,000 cu. ft. holder set in a brick tank.

The gas after being generated passes to a small relief holder, thence to the station meter, then to the holder, and from there to the governor, which is located in the office building. After the pressure is regulated it goes to the mains for distribution. There are about 125 consumers, but very little street lighting. The plant is working finely, the machines have been in constant use since completion and not one penny has been spent for repairs.

The acetylene town plant at Litchfield, Conn., was started Nov. 19, and completed Jan. 15, 1900. This plant consists of about 35,500 ft. of 3 to ¾-in. pipe, of which 24,000 ft. is 1 in.

The Williamson system is used with a 2,000-ft. steel tank and holder inclosed in the generator house. The same plan was carried out on this plant as at Manchester for the generation, with the exception of placing the meter beyond the holder.

There are about 100 consumers on the system and 139 street lights, using a standard Philadelphia pattern street post and boulevard lantern on the main streets, and a turned ornamental wooden post on the outskirts. This plant is also working finely.

The acetylene town plant at Millinocket, Me., was begun Oct. 17, and completed Dec. 19, 1901. There are about 33,600 ft. of 2½ to ¾-in pipe in this place.

Here the Housson generator, an English machine built on the non-automatic principle, but feeding the carbide by hand into a hopper, is used. The generator is backed up with a 2,000-ft. steel tank and holder, all inclosed in the generator house. After the gas is made it passes through a purifying machine, then to the governor, then through the meter to the mains. There are about 100 consumers and 60 street lights supplied by the Millinocket plant.

At Marion, Mass., the municipal acetylene plant has about 5 miles of piping from 2½-in. down to 1-in. pipe. The system is automatic, using the Drake generator. There are about 100 consumers and 50 street lights.

Fort Myer, Va., has an acetylene plant. This was built by the government. There are 330 ft. of 2½-in. pipe, 1,967 ft. of 2-in., 3,980 ft. of 1½-in., 920 ft. of 1¼-in., 1,210 ft. of 1-in. pipe, and 1,000 ft. ¾-in. pipe. The Williamson non-automatic system is used, with a 1,500-ft. steel tank and holder. The gas passes from the generator through the water seal to the holder, from there through the drying box to the governor, then to the station meter and on to the mains. There are 22 of the government quarters, all of the barracks, administration building, guard house and band quarters on the system, and 50 street lights. There are 1,086 burners in the system. The holder gives a pressure of 4½ ins., which is reduced to 20-10ths by a governor. The lamp posts here are the standard Philadelphia pattern with boulevard lanterns.

FAILURES OF JOIST HANGERS or stirrups were discussed in our issues of Nov. 20 and Dec. 4, 1902, and two failures of this kind have recently been brought to our notice. In a large building of mill construction erected by the Deere & Mansur Co., at Moline, Ill., a floor over a driveway was supported by wooden beams carried in hangers. Two or three broke, the breakage occurring at the bend or corner. The beams were temporarily supported by 8 × 8-in. posts, and the company informs us that the matter will be remedied by putting heading castings underneath to support the beams. The building was designed by the company's superintendent and draftsman, and the builders were Collins Bros., of Rock Island, Ill. The other case was in the H. M. Hooker warehouse building, at Jefferson and Adams Sts., Chicago. Here the same make of hanger was used, and several broke, being replaced by others of a different make. The contractors for this building are the T. Nicholson & Sons Co. Mr. Pashley was the architect of the building, but only prepared the plans and had no supervision of the construction. He states that in his own practice he prefers to use hangers of his own design rather than any patented forms of hangers.

*Condensed from a paper in the "Acetylene Journal."
†Washington, D. C.

FIG. 5. DOUBLE-DECK SERVICE BRIDGE AND AQUEDUCT ACROSS THE DIVERIA NEAR THE WORKS.

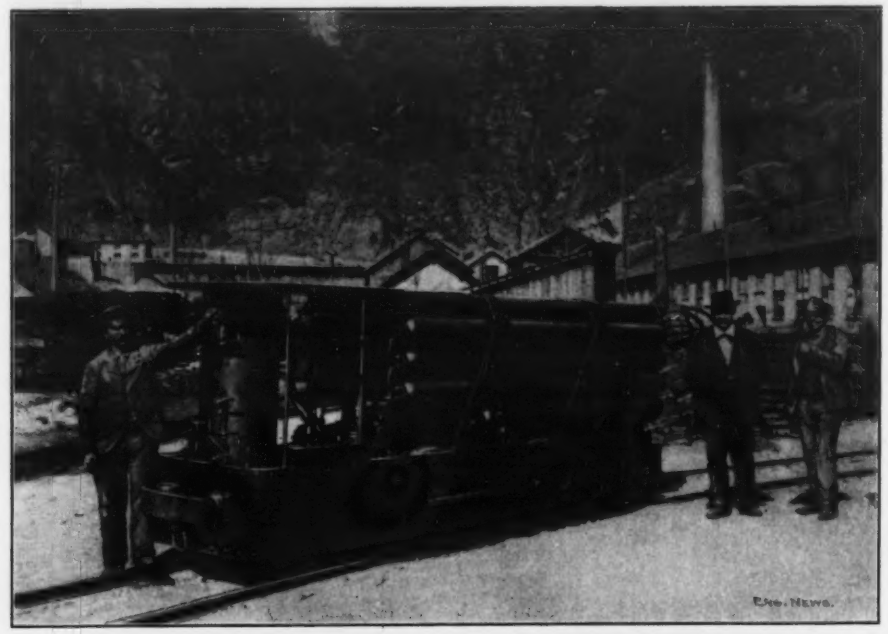


FIG. 23. VIEW OF COMPRESSED AIR LOCOMOTIVE FOR TUNNEL WORK.

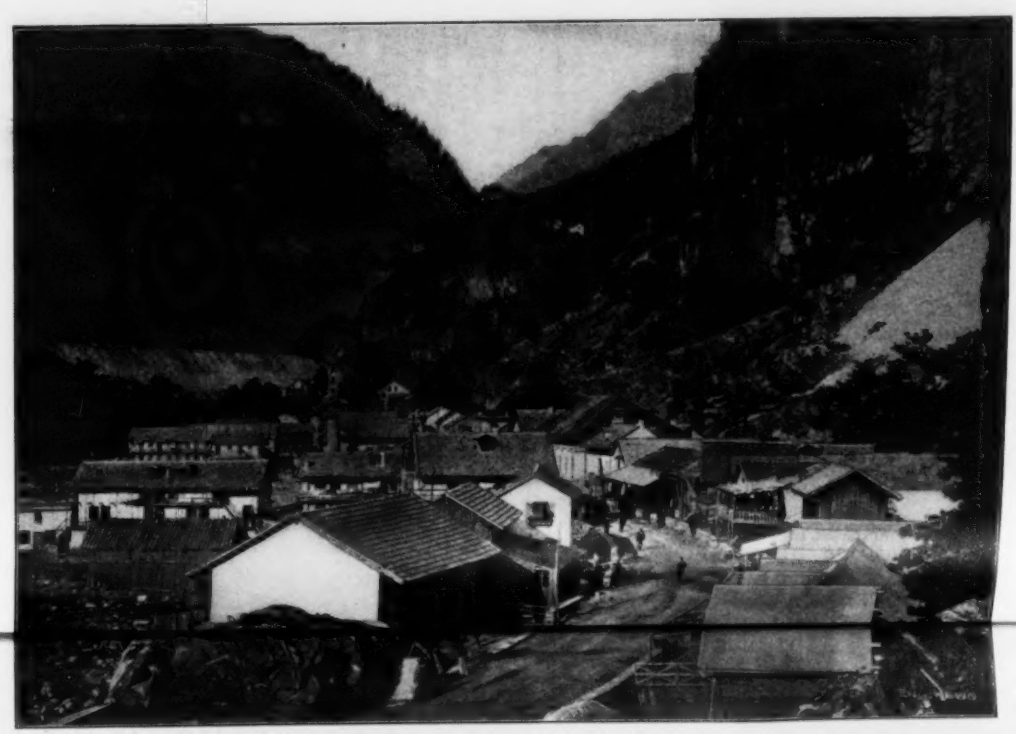


FIG. 7. VIEW OF WEIR IN ROVALE TORRENT AT BRINK OF ITS DESCENT INTO THE VALLEY OCCUPIED BY THE WORKS.

FIG. 20. VIEW OF BALMELONESCA AND MINERS' VILLAGE AT THE ITALIAN END.

FIG. 21. VIEW OF HOSPITAL AND ENGINEERS' VILLAGE AT THE ITALIAN END.

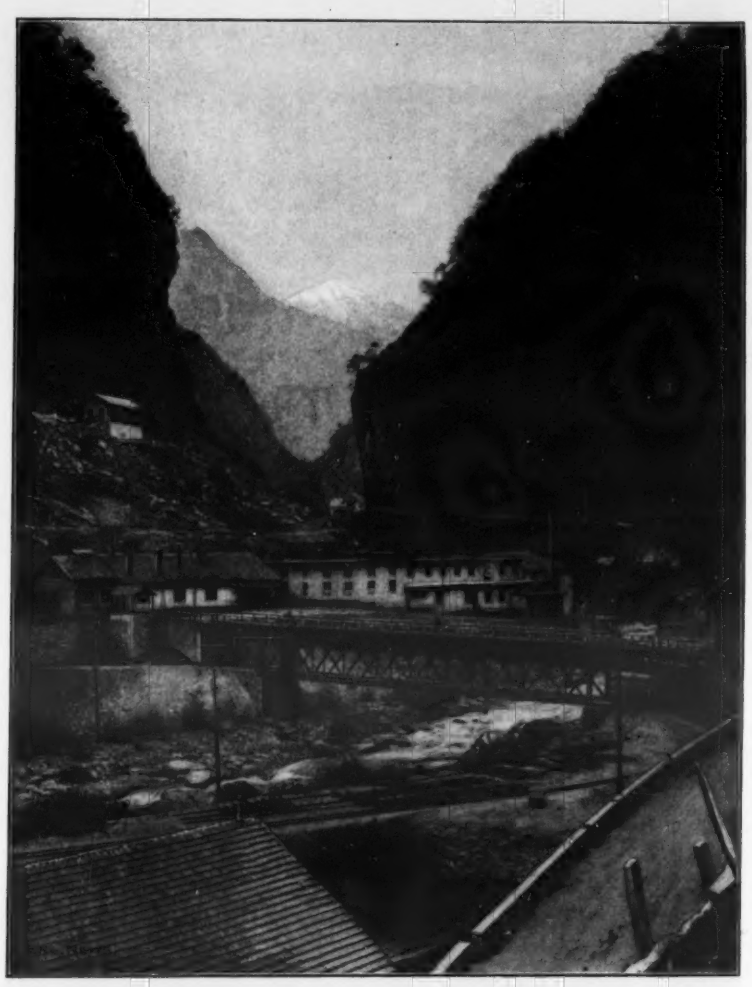


FIG. 15. GENERAL VIEW SHOWING BATHS, LAUNDRY AND BRIDGE TO TUNNEL LOOKING TOWARDS ISELLE.

THE WORKING PLANT AT THE ITALIAN END OF THE SIMPLON TUNNEL.

Brandt, Brandau & Co., Wintherthur, Switzerland, Contractors.